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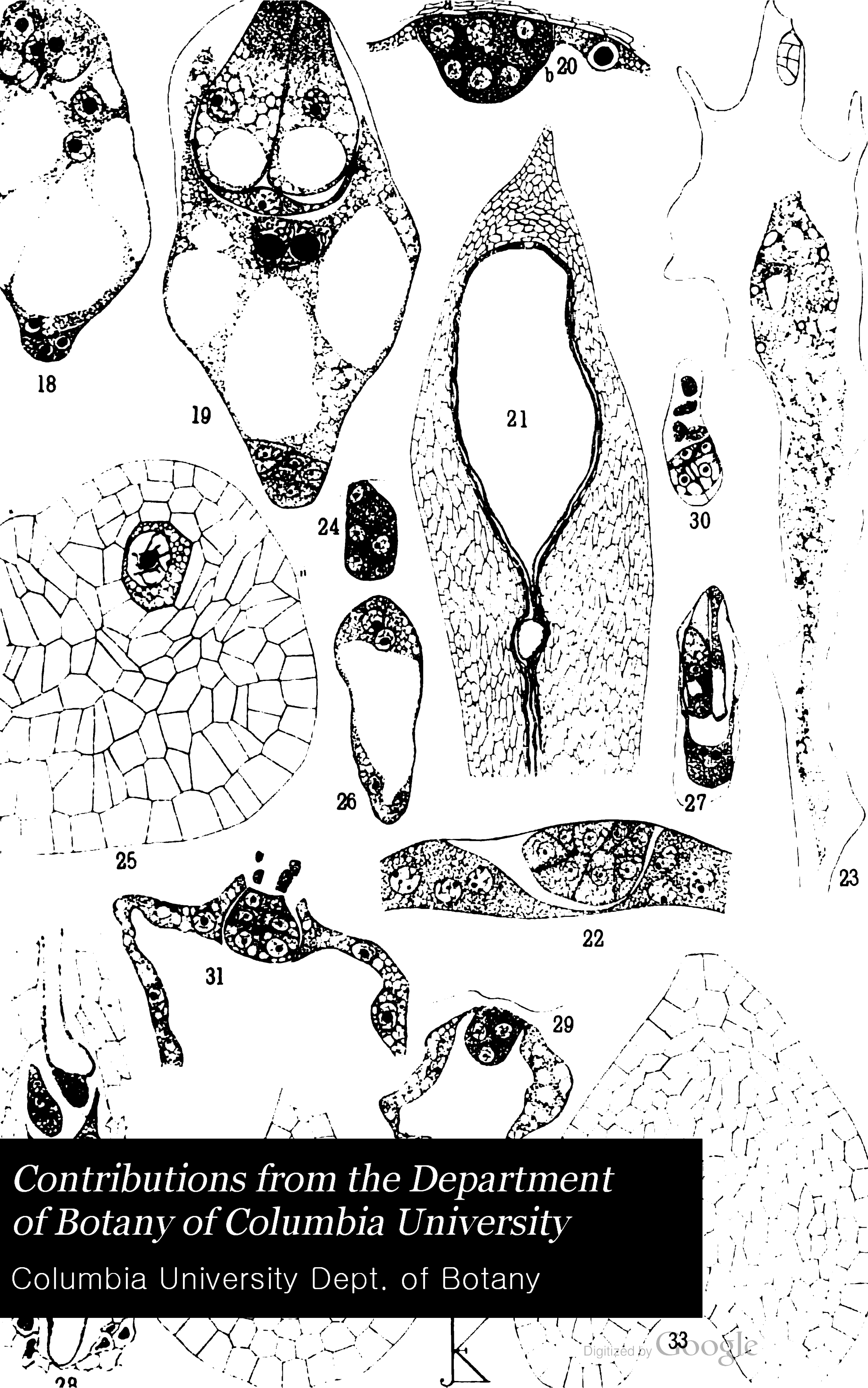

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CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
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AN INDEX TO THE DESCRIBED SPECIES OF BOTRYCHIUM

By LUCIEN M. UNDERWOOD

NEW YORK
1903

[Reprinted from the BULLETIN OF THE TORREY BOTANICAL CLUB, 30: JA. 1903.]

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An Index to the described Species of Botrychium

By Lucien Marcus Underwood

During seven years of special but more or less interrupted study of the genus *Botrychium* added to a field experience with various members of the genus extending over a quarter of a century, we have been able to see the most important collections of the world and have received a great quantity of material from numerous correspondents. Besides practically all the herbaria of this country, the foreign collections at Kew, London, Berlin, and Paris have been studied with care. As a result of this study not only have our former convictions regarding the status of the various members of the *ramosum* and *ternatum* groups been confirmed, but additional species in both these groups, together with two new representatives of the *Virginianum* group can now be properly segregated.

With the most recent publication of an African species, some members of the genus are now found on every continent and in every zone in which a land-area exists. The first index to the species was published by Milde,* who early gave an elaborate account of the variations of the species known to him. Great authority has hitherto been attributed to his opinions, which he published a generation ago, but it must ever be remembered that he based his conclusions, except among the central European species which he knew in the field, on exceedingly meagre data. This is especially true of American material, particularly among the smaller species of the genus. The same condition remains true to this day regarding the greater part of the collections of continental Europe. When we examined the collection at Berlin in 1898 it contained only a single American specimen of *Botrychium lanceolatum* and that from Greenland, and not a single specimen of *B. neglectum*. Milde's collection was scarcely better, to judge it by his own citations, and the futility of relying on opinions based on such meagre data becomes clearly apparent when we know the real facts in the case. We mention this because we have had in this country in certain quarters too much of the now obsolete notion that "the Europeans have told us better" concerning the status of our own species. Milde recognized only ten species in 1870. Prantl * enumerated the species known to him in 1884, and although he was familiar with the principal German collections only, he still recognized fifteen species. Against these more rational estimates, the English botanists even in their latest pronouncement † can find only six species! The present list enumerates thirty-four species whose status is quite definitely known, and four others concerning which there are no materials for verification that have been accessible up to the present time. Besides the above, there is material at Kew and Berlin representing certainly one and possibly two additional species of the *ternatum* group from South America, and perhaps a third from Central America. This material can best await further study before publication. There is also evidence of a species of the *simplex* group in California that awaits further study afield.

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* Verhandl. k. k. zool.-bot. Gesell. Wien. 18: 507–516. 1868.

LIST OF THE KNOWN SPECIES OF BOTRYCHIUM

Species accepted as valid are in SMALL CAPITALS, except those herein described as new, which are in the usual **bold-faced type**. Species regarded as synonyms of other species are in *italics* with their proper equivalents. Species of uncertain standing owing to inaccessibility of types or other causes are also in *italics*, but with no equivalents indicated.

Botrychium anthemoides Presl = ? B. VIRGINIANUM.

Milde comments on this species in his paper on the Silesian ferns and gives a figure of Presl's specimen, but unfortunately gives two numbers alike on the plate, so as to leave one in doubt concerning just which is the one intended for Presl's plant. There is, however, little doubt but that the species was based on an aborted specimen of the European form of our familiar species.

BOTRYCHIUM AUSTRALE R. Br., Prodr. Fl. Nov. Holl. 164. 1810. —Australia, Tasmania, New Zealand.

Botrychium Baeckeanum Brockm. Archiv. Ver. Freund. Naturg. Mecklenburg, 170. 1863.—Description not seen; said by Milde to belong to *B. matricariae*.

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* Jahrb. Bot. Gartens Berlin, 3: 297–350. 1884.

† Annals Bot. 5: 500. 1891.

BOTRYCHIUM BIFORME Colenso, Trans. New Zeal. Inst. **18**: 223. 1886.—New Zealand.

BOTRYCHIUM BITERNATUM (Lam.) Underw. Bot. Gazette, **22**: 407. *pl. 21.* 1896.

Osmunda biternata Lam. Encyc. Meth.Bot. **4**: 650. 1797.

Botrypus lunarioides Rich.; Michx. Fl. Bor. Am. **2**: 274. 1803.

Botrychium lunarioides Sw. Syn. Fil. 172. 1806.

Botrychium fumarioides Willd. Sp. Pl. **5**: 63. 1810.

Botrychium fumariae Spreng. Syst. Veg. **4**: 23. 1827.

South Carolina, Georgia, Florida, Alabama, Louisiana.

BOTRYCHIUM BOREALE Milde, Bot. Zeitung, **15**: 880. 1857.—Scandinavia, Northern Asia, Alaska.

Botrychium brachystachys Kunze = B. VIRGINIANUM MEXICANUM.

Botrychium brevifolium Ångstr. Bot. Notiser, 40. 1866.—Plant not known. Description even not yet seen and the plant was unknown to Milde.

Botrychium Breynii Fries = B. MATRICARIAE.

BOTRYCHIUM CHAMAECONIUM Bitter & Hieron.; E. & P. Nat. Pflanzenf. **1**^{4}: 471. 1900.—Africa (Kamerun).

BOTRYCHIUM CICUTARIUM Sw. Syn. Fil. 171. 1806.—Santo Domingo.

This species was based on Plumier, *pl. 159*, from Santo Domingo. Later writers have confused various species with it, as J. D. Hooker,* who applied the name to a New Zealand species of the *ternatum* group! Moore made it a sub-species of *B. Virginianum.* To this day, however, no specimens of *Botrychium* have been collected in Santo Domingo to our knowledge, and until that *terra incognita* is made known to us botanically it is best to leave the species in abeyance.

BOTRYCHIUM COULTERI Underw. Bull. Torrey Club, **25**: 537. 1898.—Yellowstone National Park, Montana, Wyoming, Idaho.

BOTRYCHIUM CRASSINERVIUM Rupr.; Milde, Nov. Act. Acad. Caes. Leop. Carol. **26**: 763. *pl. 55. f. 10, 11.* 1858.—Siberia.

Botrychium cuneatum Desv. = B. OBLIQUUM.

BOTRYCHIUM DAUCIFOLIUM Hook. & Grev. Ic. Fil. **2**: *pl. 161.* 1831.

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* Handb. New Zeal. Fl. 387. 1867.

Botrychium subcarnosum Wall. Cat. no. 49 (*nomen nudum*); Hook. & Grev. Bot. Misc. **3**: *222.* 1833.

India, Burma, Society Islands?, Samoa?.

Botrychium daucifolium β Japonicum Prantl = B. JAPONICUM.

BOTRYCHIUM DECOMPOSITUM Mart. & Gal. Mem. Acad. Sci. Bruxelles, **15**:—(15). *pl. 1.* 1842.—Mexico.

Botrychium dichronum sp. nov.

A moderately tall plant, allied to *B. Virginianum*, with sessile sterile lamina and persistent leaf of the preceding year. Roots fleshy: stem 15–20 cm. long, smooth: sterile lamina broadly triangular, 20 cm. wide, 15 cm. long, tripinnatifid with about five pairs of nearly opposite gradually diminishing pinnae, the lowermost with longer pinnules on the outer side and inclined forward at an angle; pinnules 8–10 on each side of a winged rachis, alternate, cut nearly to the midrib into 6–10 segments set at an angle of 45° with the rachis, the lower ones slightly narrowed at the base, and 3–5-toothed at the apex, all gradually simpler towards the apex of the lamina: panicle * triangular, spreading, 3 cm. or more long on a slender stalk 4 cm. or more long, 2–3-pinnate.

JAMAICA: Morce's Gap, altitude 1500 m., 7 Feb. 1900. *W. N. Clute, 96.* (Type in herb. Underwood.)

This plant was distributed as *B. Virginianum* with which it had been previously confounded and which it resembles rather closely, but differs in its peculiar short panicle, in the cutting of the lamina, and especially in its persistent sterile leaf which remains fresh until the new one is fully developed, the plant thus having two growing leaves at the time of maturity to which allusion is made in the specific name. This peculiar habit has been mentioned by both Jenman and Clute, who appear to be the only persons who have reported it from Jamaica. Its seasonal appearance also is peculiar.

BOTRYCHIUM DISSECTUM Spreng. Anleit. **3**: 172. 1804.

Botrychium ternatum, var. *dissectum* D. C. Eaton, Ferns N. A. **1**: 150. *pl. 20. f. 1.* 1878.

New England to Virginia, Ohio, Indiana and Kentucky.

While this species undoubtedly approaches in some of its forms to *B. obliquum*, we have yet to see a specimen that could not readily be distinguished in the herbarium even when shriveled by drying; in the field it often grows in the same localities as *B. obliquum* and there can always be distinguished at a glance. When it grows in the open sun it often becomes contracted and compact in habit, but the typical form of the species is so unlike *B. obliquum* that it is more rational to consider it a distinct species. (*Cf.* observations under *B. ternatum.*)

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* On the type specimen the sporophyll is not quite mature and the measurements may be a trifle too small for an average mature plant.

Botrychium erosum Milde, Bot. Zeitung, **22**: 102. 1864.

(Type from Auckland, New Zealand, *Hay;* in herb. k. k. Hofmuseum, Vienna). Milde later referred this species to his all-embracing *B. ternatum*, but this reference signifies nothing in this day of more rational conceptions of geographic distribution; without having seen the type it seems best to leave the species in doubt though it may be one of the forms of the Australasian *B. australe.*

Botrychium fumariae Spreng. = B. BITERNATUM.

Botrychium fumarioides Willd. = B. BITERNATUM.

Botrychium gracile Pursh = B. VIRGINIANUM.

BOTRYCHIUM JAPONICUM (Prantl) Underw. Bull. Torrey Club, **25**: 538. 1898.

Botrychium daucifolium β Japonicum Prantl, Jahrb. Bot. Gartens Berlin, **3**: 340. 1884.

Japan.

BOTRYCHIUM JENMANI Underw. Fern. Bull. **8**: 59. 1900.— Jamaica.

Botrychium Kannenbergii Klinsman = B. SIMPLEX.

BOTRYCHIUM LANCEOLATUM (S. G. Gmel.) Ångstr. Bot. Notiser, 68. 1854.

Osmunda lanceolata S. G. Gmel. Nov. Comm. Acad. Sci. Petrop. **12**: 516. *pl. 11. f. 2.* 1768.

Botrychium palmatum Presl, Suppl. Tent. Pterid. 43. 1845.

Scandinavia, Siberia, Alaska, to Washington, eastward to Greenland, Labrador and Newfoundland and southward to Colorado, Michigan and Pennsylvania.

BOTRYCHIUM LANUGINOSUM Wall. Cat. 48 (*nomen nudum*); Hook. & Grev. Ic. Fil. **1**: *pl. 79.* (*pl. jun.*) 1831. — India.

BOTRYCHIUM LUNARIA (L.) Sw. Schrader's Jour. Bot. **1800**^{2}: 110. 1801.

Osmunda Lunaria L. Sp. Pl. 1064. 1753.

Europe, Northern Asia, Newfoundland, Labrador, Minnesota, Colorado, Utah, and northward to Alaska and Greenland.

Botrychium lunarioides (Rich.) Sw. = B. BITERNATUM.

BOTRYCHIUM MATRICARIAE (Schrank) Spreng. Syst. Veg. **4**: 23. 1827.

Osmunda matricariae Schrank, Baier. Fl. **2**: 419. 1789.

Botrychium rutaceum Sw. Schrader's Jour. Bot. **1800**[2]: 110. 1801.

Botrychium matricarioides Willd. Sp. Pl. **5**: 62. 1810.

Botrychium rutaefolium A. Br.; Döll. Rhein. Fl. 24. 1843.

Botrychium Breynii Fries, Summa Veg. Scand. 252. 1846.

? Botrychium Baeckeanum Brockm. (*fide* Milde).

Northern Europe, Labrador, Quebec, New Brunswick, Maine, New Hampshire ?, Vermont, New York.

Botrychium matricariaefolium A. Br. = B. RAMOSUM.

Botrychium matricarioides Willd. = B. MATRICARIAE.

BOTRYCHIUM NEGLECTUM Wood, Class Book Botany, [ed. 3.] 816. 1860. — Nova Scotia to Maryland, Ohio and northward; also in South Dakota, Alaska, British Columbia, and Washington ?

BOTRYCHIUM OBLIQUUM Mühl.; Willd. Sp. Pl. **5**: 62. 1810.

Botrychium cuneatum Desv. Ann. Soc. Linn. Paris, **6**: 195. 1827.

Botrychium ternatum var. *obliquum* D. C. Eaton, Ferns N. A. **1**: 149. *pl. 20. f. 2.* 1878.

New Brunswick to Georgia, Indiana and Minnesota.

BOTRYCHIUM OBLIQUUM INTERMEDIUM Underw. Our Native Ferns, ed. 6, 72. 1900.

Botrychium ternatum, var. *australe*, sub-var. *intermedium* D. C. Eaton, Ferns N. A. **1**: 149. *pl. 20a* (*front figure only*). 1879.

New England, New York and northward. The relations of this perplexing form and its distribution are still unsettled questions.

BOTRYCHIUM OCCIDENTALE Underw. Bull. Torrey Club, **25**: 538. 1898. — British Columbia, Washington.

Botrychium Onondagense sp. nov.

A slender species somewhat intermediate between *B. Lunaria* and *B. tenebrosum* with distant wedge-shaped segments. Roots slender from a very short axis: common stalk slender, rather weak and spreading, 8–12 cm. long: lamina short-stalked (about 1 cm.), 2–4 cm. long, 1–1.5 cm. wide, composed of 7–9 broadly cuneate segments which are spaced their own width or more, with one or more notches in the outer margin, or occasionally quite deeply incised: sporophyll 1.5–2.5 cm. long, mostly bipinnate, with a slender stalk 2.5–4 cm. long.

Rocky ground in shade. The following specimens have been examined: "Geddes Farm," Syracuse, 1879, *J. S. Gifford*, C D *; Syracuse, 1873, *E. W. Mundy*, G; Jamesville Road, 1878, *Mary Olivia Rust*, U C D K E; near Split Rock, Syracuse, *Underwood* (type), U. All the stations are within five miles from Syracuse in Onondaga county, New York, where the writer first commenced the study of ferns in 1875, and to the memory of which as one of the most prolific fern localities in the country this species is dedicated. Similar plants have been collected in Michigan near Copper Harbor, Keweenaw Point, *O. A. Farwell*, U; and in Montana, Box Elder Creek, 23 July 1886, *R. S. Williams*, E.

This interesting species was originally discovered by the ladies of the Syracuse Botanical Club in June 1872; there appears to have been some difference of opinion as to whom the original discovery belongs as it was claimed by both Mrs. S. M. Rust and Miss Jane Hosmer. Mr. Davenport was the first to determine the plant and naturally confused it with the more robust *B. Lunaria* and as early as 1877 published an account of it under that name. That it may be a descendant of the stock from which *B. Lunaria* sprang, is possible, but it also has very striking relations with *B. tenebrosum*. Having collected this rare species in one of its central New York stations and being familiar with the European *B. Lunaria* not only in the herbarium but from considerable field study, we have long regarded this a distinct species, and have waited in vain for additional information before publication. We have carefully gone over the extensive suites of specimens of *B. Lunaria* in the large herbaria at Kew, Berlin, and Paris and find nothing to match this slender plant from central New York. The

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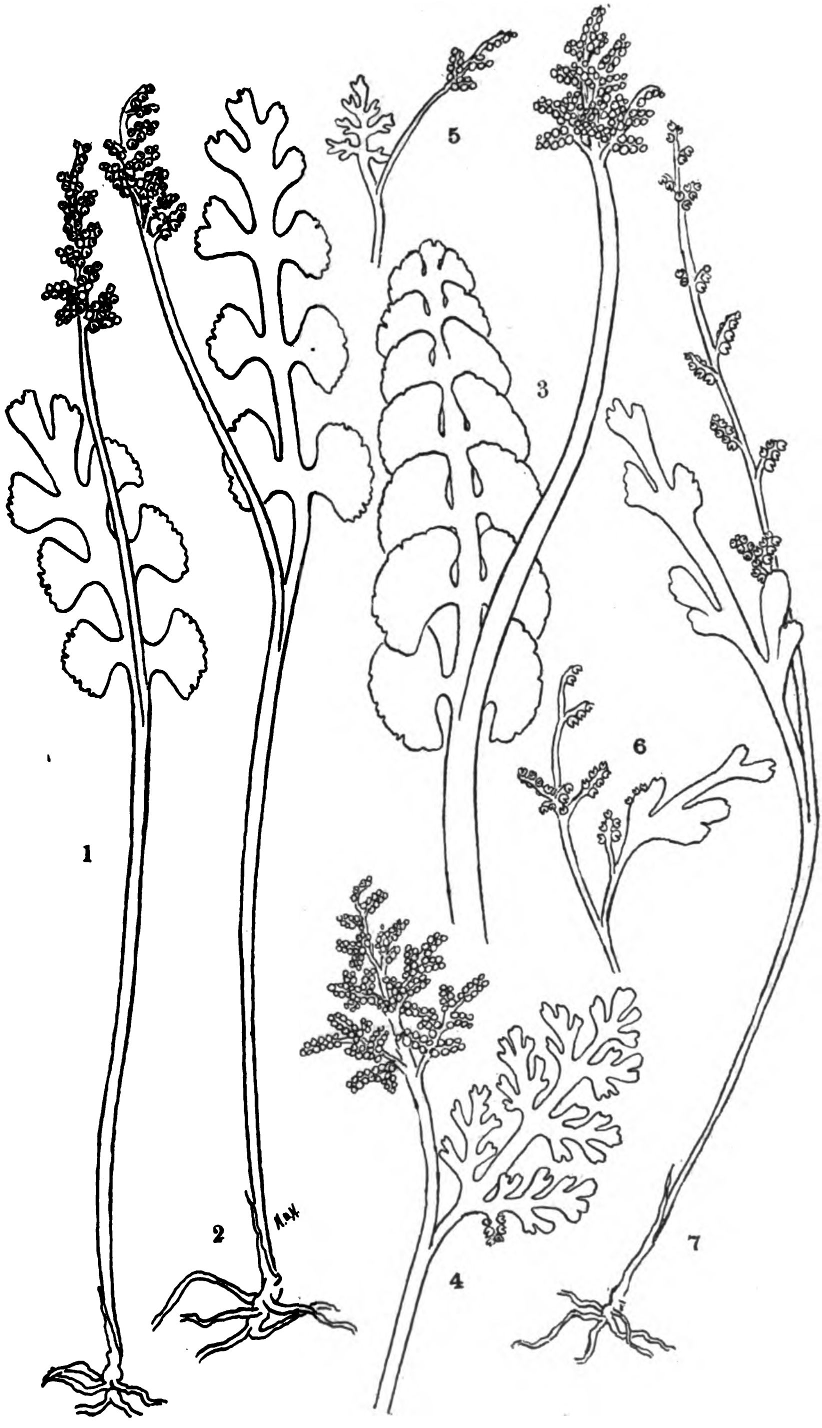
* [As noted in previous papers by Professor Underwood, published in the BULLETIN, these letters refer to the herbaria in which the specimens noted have been seen: B = Berlin; C = Columbia (and the N. Y. Botanical Garden); D = Davenport; E = D. C. Eaton; G = Gray; K = Kew; and U = Underwood.—ED.]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more slender habit, and the distant cuneate segments will readily distinguish it from *B. Lunaria.* The European species also occurs in British America and Alaska and in the high mountains of Colorado. The smaller species of this genus present as close a series as the much larger *ternatum* group and should receive more thorough field study. In this species the leaf is rarely quite short-stalked and in one or two specimens seen the number of segments is abnormally increased to fifteen. On the whole, the plant is rather nearer *B. tenebrosum*, but differs in its broader cuneate segments which are entire or flabellately lobed. In its habitat in rocky woods it is quite unlike *B. Lunaria* of Europe, which commonly grows in open meadows.

Botrychium palmatum Presl = B. LANCEOLATUM.

BOTRYCHIUM PUMICOLA Coville; Underw. Our Native Ferns, ed. 6. 69. 1900; Bull. Torrey Club, **28**: 109. *pl. 7.* 1901.—Oregon.

Botrychium pusillum sp. nov.

A low plant related to *B. matricariae*, branching below the surface of the ground and bearing small ternately compound leaves. Stem 1 cm. long (rarely longer when growing deeply), buried, pale: leaves about 3 cm. wide by 2.5 cm. long, on a short petiole 1–1.5 cm. long, the lateral divisions tripinnatifid, the terminal scarcely exceeding the lateral, the ultimate segments closely placed, rounded, wider and sometimes lobed above, 2.5–3 mm. broad, with entire margins; texture fleshy; veins imperceptible: sporophylls 4–8 cm. long (including the stout stalk), the panicle tripinnate, 3–5 cm. long.

MEXICO: Wet meadows, Sierra de las Cruces, State of Mexico, 3000 m., 11 Sept. 1892, *Pringle, 5192.* (Type in herb. Underwood.)

Differs from *B. biternatum* in its seasonal development, being autumnal instead of vernal, in its stalked leaves, and its more compact fleshy entire segments. Related more nearly to *B. matricariae* in size, but differing in its stouter form, its entire segments, and its concealed veins.

BOTRYCHIUM RAMOSUM (Roth) Ascherson, Fl. Brand. **1**: 906. 1864.

Osmunda ramosa Roth, Fl. Germ. **1**: 444. 1788.

Botrychium matricariaefolium A. Br.; Döll. Rhein. Fl. 24. 1843. (As synonym.)

Botrychium Reuteri Payot, Cat. Foug. 15. 1860.

Northern Europe. Early figured by Breyn, and differing entirely both in habit and structure from its American congener which has been confused with it.

Botrychium Reuteri Payot = B. RAMOSUM.

Botrychium robustum (Rupr.).

Botrychium rutaefolium var. *robustum* Rupr.; Milde, Nov. Act. Acad. Caes. Leop.-Carol. **26**: 763. *pl. 55. f. 9.* 1858.

Kamtschatka, Unalaska.

Botrychium rutaceum Sw. = B. MATRICARIAE.

Botrychium rutaefolium A. Br. = B. MATRICARIAE.

Botrychium Schaffneri sp. nov.

A stout fleshy plant allied to *B. obliquum* with somewhat compact glaucous foliage and copious elongated sporophylls. Stems 2–5 cm. long, stout, fleshy: leaves 10–18 cm. wide by 6–11 cm. long, on slender petioles 5–6 or rarely up to 10 cm. long; lateral divisions rather long-stalked, tripinnate; the terminal larger, sometimes quadripinnatifid below; ultimate segments oval or rarely lobed and slightly narrowed below, the margins entire, the rachises broadly winged, the surfaces bluish glaucous: sporophylls 20–35 cm. or more long on stout stalks, the panicles 6–12 cm. or more long, quadripinnate.

MEXICO: "In montibus prope San Luis Potosi," Oct. 1879, *Schaffner*, U (type) K; San Miquelito Gebirge (San Luis Potosi), *Schaffner*, *25*, C (numerous specimens); Valle de Mexico, 1875, *Schaffner*, B.

The plant is considerably smaller, more fleshy and glaucous than *B. decompositum* and is correspondingly more compact in growth and has usually shorter petioles. It is much more finely divided than either that species or *B. obliquum* to which it is somewhat related. I take pleasure in naming the species after its sole collector, Dr. Schaffner, who sent me fine specimens over twenty years ago, shortly before his death.

BOTRYCHIUM SILAIFOLIUM Presl. Rel. Haenk. **1**: 76. 1825.— California and northward.

Botrychium Silesiacum Kirschlg. Fl. Alsac. 401. 1855. Not known and description not seen.

BOTRYCHIUM SIMPLEX Hitchc. Am. Jour. Sci. **6**: 103. *pl. 8.* 1823.

Botrychium Kannenbergii Klinsman, Bot. Zeitung, **10**: 378. 1852.

New England, New York, New Jersey, Pennsylvania, ? Wyoming; Northern Europe.

Botrychium strictum sp. nov.

A tall plant with the habit of *B. Virginianum* with a sessile sterile lamina and slender spicate panicle. Roots fleshy: stems 25 cm. or more long, slender, with slightly fibrillose covering: sterile leaf broadly triangular, sessile, of three equal or subequal 2–3 pinnatifid divisions; primary pinnae 6–10 cm. long, strongly decurrent on the rachis, with 8–10 pinnules on each side which vary from oblong-lanceolate to lanceolate; pinnules varying from deeply 4–5-crenate to 5-cleft on each side, blunt or rounded at the end: panicle 6–13 cm. long, on a slender stalk 5–6 cm. long, with 16–20 short compact branches 5–15 mm. long, placed at an acute angle with the axis, thus causing the entire panicle to appear spike-like: sporangia much crowded, large, nearly 1 mm. in diameter: spores pale yellow.

JAPAN: Sapporo in groves, Aug. 1894, *A. W. Stanford* (type in the herbarium of the New York Botanical Garden); "in sylvis Takaosan., prov. Musashi, 10 Oct. 1885" comm. J. Matsamura, U. I have also seen a specimen in the Museum of the *Jardin des Plantes* at Paris, and one in the herbarium of Mr. B. D. Gilbert. The species has hitherto been reported from Japan under the name of *B. Virginianum* but it is clearly a very distinct species, differing widely in the cutting of the leaf and in the narrow spike-like panicle which is also much shorter than in our familiar species. In the new species the mature panicle scarcely overtops the sterile leaf when laid on the herbarium sheet.

BOTRYCHIUM SUBBIFOLIATUM Brack. U. S. Expl. Exped. **16**: 317. *pl. 44. f. 2.* 1854. — Sandwich Islands.

Botrychium subcarnosum Hook. & Grev. = B. DAUCIFOLIUM.

BOTRYCHIUM TENEBROSUM A. A. Eaton, Fern Bull. **7**: 8. 1899. — New Hampshire, Vermont, Connecticut, New York.

Botrychium tenellum Ångstr. Bot. Notiser, = B. RAMOSUM (*pl. jun.*).

Botrychium tenuifolium sp. nov.

A slender-stemmed species allied to *B. obliquum* but with the segments thin and reduced to nine in number. Stem very slender, 2–4 cm. long, 1–1.5 mm. thick: leaf 3.5–5 cm. long, 3–6 cm. wide, usually consisting of only nine segments (*i. e.*, strictly biternate), with the three divisions subequal; occasionally larger forms show a pair of additional lobes on the terminal division; segments ovate, 1.2–15 cm. long by 6–8 mm. wide, thin, sharply serrate, or in larger forms occasionally two or three times incised; petiole 3–6.5 cm. long, very slender: panicle 3–6 cm. long, bipinnate or rarely tripinnate below, on a slender stalk 6–22 cm. (usually 12–14 cm.) long.

Specimens have been examined as follows:

LOUISIANA: Alexandria, *Hale* (Chapman herbarium), C (type).

FLORIDA: "River banks," C. Communicated many years ago to Torrey who had endorsed it: "Seems to come near *B. simplex* Hitch."

ALABAMA: Auburn, 1895, *Underwood*, U; 15 Oct. 1896, *Earle*, C; 22 Oct. 1896, *C. F. Baker*, C; Oct. 1897, *Baker & Earle*, C.

MISSOURI: Butler county, 4 Nov. 1892, *Bush*, C.

This species is nearest related to *B. obliquum* which it appears to replace in the coastal plain of the gulf region. It is much more slender than *B. obliquum* and the leaf is not only much less divided in mature forms, but is also thinner and usually sharply serrate almost as in *B. Japonicum*. Typical forms have only nine segments to the leaf.

BOTRYCHIUM TERNATUM (Thunb.) Sw. Schrader's Jour. Bot. **1800**^{2}: 111. 1801.

Osmunda ternata Thunb. Fl. Jap. 329. *pl. 32.* 1784.

Japan, China, India.

A number of species were referred to this species as varieties by Milde, and the practice is still followed by some of his modern admirers. There seems to be no difference of opinion relative to the existence of the groups of individuals as distinct groups, the only difference appearing to be the rank that shall be assigned to them. The *ternatum* group represents a closely allied group of forms that appear to have become widely scattered from some common center. There is no rational doubt but that they have had a common origin; this of course is the only possible explanation of their structural and habital relationship. Now where was the original center from which they sprung? According to the system that would make them varieties of *B. ternatum* because that species *happened* to be the first described, it would seem to follow that that centre was in Japan, otherwise they could not be varieties of a Japanese species. The current system of naming varieties is a stupid practice handed down to us from the past and is wholly at variance with the modern conceptions of evolution. The original centre in all probability was *not* in Japan so that the members of the *ternatum* group are not varieties sprung from *B. ternatum*, and it creates a false impression to continue to call them so. They are distinct *things* as everyone admits, and we maintain it is more rational and more in accord with our conceptions of evolutionary origin from a common stock to call them species. It is also much simpler and leaves us free to determine the original centre of distribution and relationship without prejudice. The practice of naming varieties on slight environmental characters ought to cease, and botanists should discourage the naming of such trivialities. A marked example of how far this reduction of species to varieties can be carried is seen in Dr. Christ's reduction of *Dryopteris marginalis* and *D. Goldieana* to varieties of *D. filix-mas*. For a European who has never seen either of the species growing in its native habitat to take such liberties with American species is to say the least violating the code of international courtesy and ought to stand as a warning to those who still hold to the ancient heresy that Europeans know more about the American flora than we do ourselves.

BOTRYCHIUM VIRGINIANUM (L.) Sw. Schrader's Jour. Bot. **1800**[2]: 111. 1801.

Osmunda Virginiana L. Sp. Pl. 1064. 1753.

Botrychium gracile Pursh, Fl. Am. Sept. **2**: 656. 1814.

Botrychium anthemoides Presl, Abh. Böhm. Ges. Wiss. **5**: 323. 1847.

BOTRYCHIUM VIRGINIANUM MEXICANUM Hook. & Grev. Bot. Misc. **3**: 222. 1833.

Botrychium brachystachys Kunze, Linnaea, **18**: 305. 1844.

Mexico. Moore referred this to *B. cicutarium*, which he made a subspecies of *B. Virginianum*. The species or variety appears to be quite rare in collections although Mr. Pringle once wrote me that it was quite common in Mexico. It is desirable that it be compared in the field with more northeastern types of the species. The region of Mexico has been widely traversed by Mr. Pringle and others who have brought to light a large number of new species, but they have almost as systematically neglected to collect the old ones, and consequently our knowledge of the distribution of

Mexican plants is still lamentably defective. The whole Mexican region will have to be gone over piecemeal, and collections made that will give some conceptions of the distribution of many of the species of that prolific country. Among them is this Mexican representative of our common rattlesnake fern of which scarcely any specimens exist in American collections.

[The figures on page 49 illustrate four species: *f. 1, 2* = *Botrychium Onondagense*; *f. 3* = *Botrychium Lunaria*; *f. 4, 5* = *Botrychium neglectum*; *f. 6, 7* = *Botrychium tenebrosum.*]

COLUMBIA UNIVERSITY,
25 December 1902.

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The Memoirs already published are:—

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The Contributions have now reached the ninth volume.

Vol. I. Nos. 1–25 (1886–1892). Out of print, except Nos. 6, 7, 11, 13, 17, 20, 21, 22, 24. These can be supplied at twenty five cents each, except No. 6, which is one dollar.

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* Nos 157 and 158, with the set of nine papers by Mr. Bicknell on *Sisyrinchium*, can be had for one dollar and fifty cents.

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CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 202

STUDIES IN PLANT HYBRIDS: THE SPERMATOGENESIS OF HYBRID COTTON

By WILLIAM AUSTIN CANNON

NEW YORK
1903

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Studies in Plant Hybrids: The Spermatogenesis of Hybrid Cotton

By William Austin Cannon

(With Plates 7 and 8)

Introduction

Perhaps the first suggestion that we have as to the possibility of crossing two or more less distantly related plants was given by Camerarius * in his letter to Valentini on the sexuality of plants. This was in the year 1694. In this letter Camerarius speculates as to the effect of crossing the hemp (*Cannabis*) and the hop (*Humulus*), wondering whether the posterity of the form used as the mother would by this cause be altered. He did not make the cross, and in fact it was not until 1760 that the first plant hybrid which was of use to science was made. In that year Kölreuter,† perhaps the greatest as he was the first of hybridizers, crossed *Nicotiana paniculata* ♂ and *N. rustica* ♀ and obtained fertile offspring, and thus began successfully the experimentation which he carried on with so great results for several decades.

The first plant hybrid thus empirically formed served a good purpose by providing incontestable evidence upon certain of the leading biological questions of the day. It fortunately was of the intermediate type, and thus the fact that both parents contributed equally to the formation of the hybrid offspring demonstrated at once the falsity of the evolution or preformation hypothesis, gave

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* Camerarius, Ueber das Geschlecht der Pflanzen, translated from the Latin "De sexu plantarum epistola." (Ostwald's Klassiker der exakten Wissenschaften, 105 : 49. 1899.)

† Kölreuter, Vorläufige Nachricht von einigen das Geschlecht der Pflanzen. (Ostwald's Klassiker der exakten Wissenschaften, 41 : 30. 1893.)

[The preceding number of the Bulletin, Vol. 30, No. 2, for Febuary, 1903 (30: 75–132), was issued 28 F 1903.]

a strong support to the idea of sex in plants, and also pointed the way to the true conception of fertilization.

In addition Kölreuter, in the course of his long career as a hybridizer, arrived at other results that were of almost equal importance. For instance, he first pointed out the meaning of the visits of insects to flowers, and thus formed the basis for Sprengel's subsequent work, and he first showed the significance of nectar in this connection.* Kölreuter also introduced the "modern" methods in experimental research, as a single illustration taken from many will suffice to show. He had the mistaken idea that the part of the pollen necessary to insure fertilization was the fluid which he had observed about it and which he supposed originated in the interior of the grain and oozed out through the pores. He therefore was interested to learn how many grains were required to effect fecundation. To ascertain this he counted the grains in a flower and artificially pollinated with a varying but a known number. In *Hibiscus Trionum* he counted 4,863 grains, and found that only 50–60 were necessary to fructify more than 30 ovules. In *Mirabilis Jalapa* and *M. longiflora* two or three, or only one were required to fertilize the single ovule.

Kölreuter recognized all of the important characteristics of plant hybrids.† He learned that species-hybrids were as a rule intermediate and uniform, whichever race provided the male or female parent. He observed the fruitfulness of variety-hybrids, the sterility or lessened fruitfulness of those between species, the stronger growth of many hybrids and other phenomena. In his experiments Kölreuter used mainly the following genera: *Aquilegia, Matthiola, Dianthus, Melandrium, Linum, Malva, Lavatera, Lobelia, Nicotiana, Datura, Lycium, Verbascum, Digitalis* and *Mirabilis.*

About the time that Kölreuter was engaged in the experimental study which gave such remarkable results, Linné, ignoring that scientist's work, put forward theories in which hybrids played a prominent rôle. And this was done with hardly any experimental basis for his ideas. I refer to Linné's hypotheses regarding the origin of genera and species. According to Sachs (*l. c.*

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* Sachs, Geschichte der Botanik, 440. 1875.

† Focke, Die Pflanzen-Mischlinge, 431. 1881.

114) the doctrine is in brief this, in the first place classes were created, by the subsequent mixing of the individuals of the different classes genera arose, and finally by the crossing of these genera species were differentiated.

It was not long however before some practical tests were made of the relation of the constancy of species to the possibility of deriving fertile hybrids by crossing them. Apparently without an adequate reason for his belief, Sprengel thought that crosses between distinct natural species might be fertile, and he accordingly is pleased to discover means by which plants may resist hybridizing, as for instance the difference in season of the maturation of the reproductive organs. This is considered by him as a miraculous adaptation for the preservation of the purity of the species.

The relation of Kölreuter's results and methods to the science of his time is so well given by Sachs that I shall quote a paragraph direct (*l. c.* 446): "Der allgemein theoretische Werth von Koelreuter's künstlichen Pflanzenbastarden ist gar nicht hoch genug anzuschlagen; die Vermischung der Eigenschaften der väterlichen und mütterlichen Form war der stärkste Beweis gegen die Evolutionstheorie und liess gleichzeitig einen tiefen Blick in das wahre Wesen der sexuellen Vereinigung thun. Auch ging aus Koelreuter's zahlreichen Untersuchungen sofort hervor, dass nur ganz nahe verwandte Pflanzen und auch diese nicht immer einer geschlechtlichen Vereinigung fähig sind, wodurch die vagen Vorstellungen Linné's für jeden Urtheilsfähigen sofort beseitigt wurden, wenn es auch immerhin noch lange dauerte, bis die Wissenschaft alle Vortheile aus Koelreuter's Untersuchungen zog. Die Pflanzensammler aus der Linné'schen Schule ebenso, wie die eigentlichen Systematiker am Ende des vorigen Jahrhunderts, hatten kein Verständniss für derartige Leistungen, ja Koelreuter's Ergebnissen zum Trotz, verbreiteten sich in der botanischen Literatur später unrichtige Vorstellungen über Bastarde und ihre Fähigkeit sich fortzupflanzen; den Gläubigen der Constanzlehre konnten die Bastarde ohnehin nur unbequem sein, sie störten ihnen die Reinlichkeit des Systems und passten zudem nicht recht zu der Annahme, dass jede Species eine 'Idee' repräsentire."

Whether hybrids between parents of different species are always sterile, and those between varieties always fertile, soon became a question of great importance, since by this means it was hoped that a distinction between varieties and species might be had. Early in the nineteenth century the question was taken up by English and later by French botanists and since the facts were not well known the bearing of them on the question under discussion was also much in dispute. In England, Herbert * and Knight † discussed the relative fertility of species- and variety-hybrids, the latter author holding that hybrids from parents of different species are always sterile, but on the other hand that the varietal hybrids are always fertile. From the results of his experiments and study Knight concluded also that fruitful hybrids indicate that the parents are not distinct species, but varieties of the same species. Herbert on the contrary found that hybrids between different species are not seldom fertile. As to the significance of this he does not appear to think the parents were of the same species, but rather (*l. c.* 16) that they "have branched out from one common stock since the creation of the world." He further says: "If it be admitted, that diversity of species could have been produced by variations of soil, temperature, or humidity, it will be readily understood that such diversity might have been further multiplied by hybrid intermixture, as the species were brought together by the natural progress of their diffusion."

It will not be necessary for the purposes of this paper to enter more into the details of this phase of the "constancy of species" doctrine. The ground that Knight and Herbert threshed over in England was gone over again later (1862) in France by Naudin and Godron.‡ Finally, Darwin § has pointed out that not only is the fertility or sterility of a hybrid no criterion of the relationship of the parents, but that the hybrid may even be more fruitful than either pure parent.

Focke (*l. c.* 443) says that up to the time of Nägeli (1865) the knowledge of hybrids was unconnected and fragmentary, and that this author united and made coherent the results of the earlier hybridizers. Especially he drew consistent conclusions from the facts gathered together by Gärtner. The general conception of hybrids held at the present is based on Nägeli's writings. He noted the tendency of hybrids to vary, and to revert, and he showed the value of the reciprocal cross, and, finally, he formulated the laws governing the action of hydrids. He also observed the behavior of hybrids in the second and later generations when they were inbred, although the significance of this was of course not appreciated by him.

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* Herbert, On the Production of Hybrid Vegetables. Trans. Hort. Soc. Lond. 4: 15. 1820.

† Knight, Observations on Hybrids. Trans. Hort. Soc. Lond. 4: 367. 1821.

‡ Focke, Die Pflanzen-Mischlinge, 441. 1881.

§ Darwin, On the Origin of Species, Am. ed., 235. 1883.

At the time when the work of Nägeli was being published, that of Gregor Mendel * had been recently presented to the society at Brünn. His main theme was to account for the behavior of hybrids in the second and later generations. It will not be necessary in this place to present a full account of Mendel's laws because since their rediscovery by de Vries,† Correns,‡ and Tschermak § they have been put out unabridged both in their original form ‖ and in English translation,¶ and have been explained by several writers. ** For convenience of reference I shall however give a brief outline of Mendel's results and conclusions taken mainly from my previous paper.††

When one pure form (*A*) is crossed with another pure form (*a*) the hybrid of the primary cross shows the *A* characters only. When, however, the hybrid plants of this generation are fertilized among themselves and produce offspring the *a* characters are seen, and in a definite proportion to the form bearing the *A* characters. These constitute the hybrids of the second generation. If now the hybrids of the second generation are fertilized in such a manner that plants with *a* characters are crossed with those bearing the same characters, and likewise plants bearing *A* characters with forms like themselves, the resulting hybrids will behave in a manner characteristic of the respective cross. That is (1) the plants with *a* characters will be found to transmit those characters only, *i. e.* they are "fixed"; and (2) when the plants with *A* characters are fertilized with other plants bearing the same characters, that is to say, if inbred, two sorts of hybrids will result: one portion will bear only the *A* characters, which may be demonstrated by breeding as before, and one portion, apparently also with *A* characters only, will be found to vary just as the hybrids of the primary cross varied, *i. e.* this will be really mixed or hybrid. This general scheme may be better understood if tabulated as follows:

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* Mendel, Versuche über Pflanzen-Hybriden. Abh. Naturf. Ver. Brünn, 4: 3. 1866.

† De Vries, Das Spaltungsgesetz der Bastarde. Ber. Deuts. Bot. Gesells. 18: 83. 1900; Ueber erbungleiche Kreuzungen. Ber. Deuts. Bot. Gesells. 18: 435. 1900; Sur les unités des caractères spécifiques et leur application a l'étude des hybrides. Rev. Gèn. Bot. 12: 257. 1900.

‡ Correns, G. Mendel's Regel über das Verhalten der Nachkommenschaft der Rassenbastarde. Ber. Deuts. Bot. Ges. 18: 158. 1900; Gregor Mendel's "Versuche über Pflanzen-Hybriden" und die Bestätigung ihrer Ergebnisse durch die neuesten Untersuchungen. Bot. Zeit. 58^2: 229. 1900.

§ Tschermak, Ueber künstliche Kreuzung bei *Pisum sativum*. Zeitschr. Landw. Versuchswesen Oesterr. 5: 465. 1900; Ber. Deuts. Bot. Gesells. 18: 232. 1900.

‖ Ostwald's Klassiker der exakten Wissenschaften, No. 121. 1901.

¶ Jour. Roy. Hort. Soc. Lond. 26: 1. Au 1901.

** Bateson & Saunders, Experimental Studies in the Physiology of Heredity. Rep. Evolution Committee Roy. Soc., Report 1. 1902; Emerson, Agric. Exp. Sta. Neb. Rep. 15: 30. 1902; Spillman, Science, II. 16: 709. 1902; Pop. Sci. Month. 62: 269. Ja 1903.

†† Cannon, A Cytological Basis for the Mendelian Laws. Bull. Torrey Club, 29: 657. D 1902

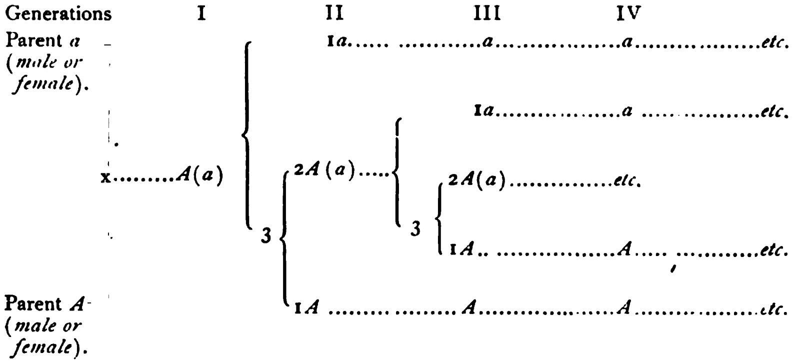
Generations
I
II
III
IV
Parent *a* (*male or female*).
x.........*A*(*a*)
1*a*..........*a*..........*a*..........*etc.*
1*a*..........*a*..........*etc.*
2*A*(*a*).....
2*A*(*a*)..........*etc.*
3
3
1*A*..........*A*..........*etc.*
Parent *A* (*male or female*).
1*A*..........*A*..........*A*..........*etc.*

FIG. 1. Explanation: *A*, dominant character; *a*, recessive character; *A*(*a*), a hybrid having both characters of which (*a*) is masked by *A*.

Not only do the hybrids vary thus in a regular manner, but there is also a definite proportion of recessives (*a*), and dominants (*A*), as the table indicates. That is, referring to the table, in the second generation one fourth of the offspring is recessive (*a*), and three fourths apparently dominant (*A*), but really composed of two sorts (*A*(*a*)) one third of these being dominant (*A*), two thirds mixed (*A* (*a*)). The latter continue in the succeeding generation to vary just as the hybrids of the primary cross varied, one fourth of their offspring being recessive, one fourth dominant and one half mixed.

The regularity in the variation as just described in the second and later generations is accounted for by supposing that the hybrids of the first generation organize germ-cells which are of pure descent, and that these unite in fertilization according to the laws of chance. Taking a specific case by way of illustration, we can imagine the following to take place, when the sex-cells of say the second generation hybrids ($A(a)$) meet each other in fecundation. The pollen, which is of pure descent, unites with the egg, which also is of pure descent, and the chances of union may be thus expressed: $A\ A$; $A\ a$; $a\ A$; $a\ a$. So that it happens, since the anther forms two sorts of germ-cells and the ovaries also two sorts, that in this way one half of the hybrids of say the third generation will be of mixed descent, and one half pure, the latter being equally recessive and dominant. The results, as calculated by the laws of chance, are thus seen to be precisely the same as what is found empirically to occur.

Such may perhaps be considered the more essential facts and conclusions of the discovery of Mendel, and upon them are based the two so-called "laws" of Mendel, namely, the law of dominance and that of the splitting of the hybrid race.

Mendel gives also, and in much detail, the results when the pure parents of hybrids are separated by more than one character, as, for instance, by *two* or *three*. But his experiments are too extensive to present here and I can not do better than to quote from the account of them by Bateson (*l. c.* 9). "In both sets of experiments the numbers of individuals and their constitution * * * were consistent with the hypothesis arrived at in the case of varieties differing in respect of one character, namely, that each male and female cell of the cross-bred is pure in respect of one character of each pair of characters, and is capable of transmitting this character to the exclusion of the opposite character; that the reproductive cells are, in the cross-breds, of as many kinds as there are possible combinations of pure characters (taken two or three together, as the case may be); and, finally, that each kind is represented in the cross-breds on the average in equal numbers."

In considering the probable bearing of Mendel's discovery on the biological sciences I can do no better than to quote at some length from Bateson's recent report, but of course I shall not attempt to present a summary of all of this author's conclusions.

Bateson says (*l. c.* 125): "With the discovery of the Mendelian principle the problem of evolution passes into a new phase. It is scarcely possible to overrate the importance of this discovery. Every conception of biology which involves a knowledge of the physiology of reproduction must feel the influence of the new facts, and, in their light, previous ideas of heredity and variation, the nature of specific differences, and all that depends on those ideas must be reconsidered, and in a great measure modified."

So much for the scope of the Mendelian principle. Bateson then cites specific examples, well known to breeders and scientists, which have hitherto been puzzling enough but which are apparently well explained by the discoveries of Mendel. Among these may be mentioned (1) the skipping of a generation, (2) the appearance in a pure strain of "rogues," and (3) the inability of breeders to fix by selection certain forms. The first is an integral part of the Mendelian conception and therefore need not be spoken of further here. The "rogues" which appear in apparently pure strains are supposed to be recessives, while in such instances the characters desirable for fixation are the dominant ones. And the last case will be best explained by the author himself. At page 131 he says: "It has long been known to breeders that certain forms cannot be fixed by selection indefinitely continued. In other words, though they produce offspring like themselves, they have also a large number which do not resemble them.

"A case of this kind is seen in breeding crested canaries. The kind of crest desired for exhibition can, according to canary-fanciers, be produced most easily by mating crested birds with non-crested, or plain heads as they are called. If it is supposed that the crested character is usually dominant, we have a simple explanation. When crested birds are bred together a number of birds are produced whose crests are coarse and stand up and others without crests. The latter are the recessives; the former we may suppose to be the pure dominants. What the fancier wants is a crest composed of long feathers lying evenly down over the head.

These may be the heterozygotes,* and consequently cannot breed true or be fixed by selection. Such birds bred together, give many plain heads and birds with coarse crests."

Bateson also speaks of the relation of other phenomena to the Mendelian conception, such as *continuous* or *discontinuous variation, prepotency and the determination of sex,* but it will not be necessary in this connection to quote more at length.

Although the foregoing account of the relation of the history of hybridizing to that of the other biological sciences is from necessity an outline only, I think it can be seen that hybridization has at various times played an important rôle, and occasionally a definitive one, in aiding the solution of perplexing biological problems.

THE RESULTS OF EXPERIMENTAL HYBRIDIZATION

Florists and gardeners have long employed the crossing of closely related plants † as a means of obtaining new and useful races and it is without doubt largely due to them that so much is at present known about the behavior of plant hybrids. To the practical as well as to the theoretical hybridizer the manner of the transmission of the parental characters, the fertility or sterility of the hybrid, and the variation of the hybrid race are of the highest importance.

The variation in hybrids is dependent on the manner in which they reproduce parental characters. These characters may be blended in the hybrid, they may be associated in a variety of ways, or the hybrid may recapitulate in detail the characters of either parent. Moreover, the hybrid of the primary cross may show variation to a different degree from that of the second, or of the later generations. The phenemona in the first generation are the essentials of what is commonly understood by the term hybrid, and as such are described in all literature of the subject; the behavior of the hybrids in the second and following generations, although of the greatest importance, has been little studied.

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[*] By "heterozygote" is evidently meant a hybrid, apparently only dominant, but really with both opposing characters ("allelomorphs" of Bateson, "Paarlings" of Correns) united to form the "zygote"; in the "homozygotes," on the other hand the characters of the pair are alike.

[†] Compare Richard Bradley's "New Improvements of Planting and Gardening, both Philosophical and Practical," p. 16. London, 1726.

The variations of the hybrids are many and complex, and it would be impossible as well as unnecessary for the purposes of this paper to attempt to present anything like a full account of the subject, much less to give a very complete list of hybrids to illustrate the variations. What I shall give is largely drawn from the work of Focke already quoted, and a shorter one by Swingle and Webber,* although I shall not confine myself wholly to these sources.

The characters of the parents may be perfectly blended in the hybrid so that neither parent is "favored" (*Datura Metel* × *D. meteloides*, *Geum intermedium* †). In other cases the hybrid may not be intermediate but may exhibit all grades of the characters by which the parents are distinguished from each other (*Abutilon* hybrids), even reproducing in great detail either parent (*Hieracium* hybrids, those of the maize, *Cytisus Adami* ‡ and the pods of some hybrid peas, etc. §). Or the hybrid may show the characters of either parent without intermediate grades (strawberry hybrids). The foregoing refers to the behavior of the hybrids of the first generation, or those of the primary cross; in the second generation the variations are equally well marked.

In the second generation the hybrids that were intermediate and uniform in the first one may remain so (*Geum intermedium*, Burbank's raspberry-dewberry hybrid). Or such hybrids may vary (*Nicotiana rustica* × *N. paniculata*). Hybrids which present variations in the first generation tend to become more variable in the second and third generations. Those that in the first generation resembled either parent may continue to revert in a similar manner (strawberry hybrids), or an intermediate condition may be present in addition to the extreme racial forms (*Datura Metel* × *D. meteloides*).

Another phase of variation is found in the changes that a hybrid may exhibit in the course of its life, or ontogeny. In the earlier stages it may show the characters of one parent, and in the later ones those of the other. For example, hybrid *Tropeolum* which was intermediate at the beginning of the season, reverted later to the mother form with intermediate grades [*]; in spring the leaves of hybrid *Cistus* and *Populus* may show characters of one of the parents, and in the autumn those of the other; or in other hybrids (*Melandrium album* × *M. rubrum*, *Epilobium roseum* × *E. montanum*) the flowers may change during the blossoming from the characters of one parent to those of the other; or this may take place in different years (*Bletia crispa* × *B. cinnabarina*, *Galium cinereum* × *G. verum*).

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* Swingle & Webber, Hybrids and their Utilization in Plant Breeding. Yearb. U. S. Dep. Agric. 1897: 383. 1898.

† Salter, On the Fertility of certain Hybrids. Phytologist, 4: 737. 1852.

‡ Farmer. Ann. Bot. 11: 538. 1897.

§ Tschermak, Weitere Beiträge über Verschiedenwerthigkeit der Merkmale bei Kreuzung von Erbsen und Bohnen, Ber. Deuts. Bot. Gesells. 19: 35. 1901.

In another sort of hybrids the parental characters may reappear side by side — these are the so-called "mosaic" hybrids. They usually result from the union of closely related parents. As a single example of mosaic plant hybrids, that produced by crossing *Rhododendron Rhodora* × *R. calendulaceum* may be cited. In this case the flower has the colors of the flowers of both parents, and these are reproduced unchanged and stand side by side. Darwin [†] gives an example of an interesting mosaic animal hybrid. He says "the hairless condition of the Paraguay dog is either perfectly or not at all transmitted to its mongrel offspring; but I have seen one partial exception in a dog of this parentage which had part of its skin hairy, and part naked; the parts being distinctly separated as in a piebald animal."

Occasionally the hybrids are invariable and come true to seed. Such a one is the *Oenothera* hybrid of de Vries,[‡] formed by the union of *O. rubrinervis* and *O. nanella*, which has been grown several generations without reversion. Another case may be mentioned out of many, namely, that of the *Geum* hybrid already referred to. This plant is a natural hybrid in certain parts of England, and was formerly supposed to be a distinct species. Salter [§] reproduced the hybrid by crossing *G. rivale* and *G. urbanum*. All of these hybrids were uniform and intermediate, and came true to seed for many generations.

Still another class of inheritable characteristics may well be mentioned; I refer to the transmission of such characters as hardiness, or the reverse of this, the ability to withstand warmer climates. Of the former the hybrid between *Montbretia Pottsii* and *Tritonia aurea* is given by Swingle and Webber (*l. c.* 414), who also present the Le Conte and Kieffer pears as examples of the latter. These writers say (*l. c.* 416) that the "adaptability of the Kieffer and Le Conte pears to growth in warmer climates is doubtless derived from the mother," that is, the Chinese sand pear. The ability to resist diseases is another transmissible character. The French varieties of grapes have been made resistant to phylloxera by crossing with hardy American forms. The hybrid may also be different from either parent in qualities analogous to the above. For example, it may be more vigorous than either parent, or may attain a larger size. Such variations are found in the offspring of closely related plants. The walnut hybrid of Burbank (*Juglans regia* × *J. Californica*), mentioned by Swingle and Webber, "grows twice as fast as the combined growth of both parents. * * * The wood is very compact, with lustrous, silky grain, taking a beautiful polish, and as the annual layers of growth are an inch or more in thickness and the medullary rays prominent, the effect is unique."

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[*] Darwin, Animals and Plants Under Domestication, Am. ed., 1: 470. 1868.

[†] Darwin, *l. c.* 2: 117.

[‡] De Vries, Die Mutationstheorie, 1: 461. 1901.

[§] Salter, *l. c.* 739.

We shall take up now briefly the relative sterility or fertility of hybrids, and what is closely associated with it, the limits of a cross.

Focke * says that, as a general rule, "je näher die morphologische und systematische Verwandtschaft der Stammformen ist, um so weniger pflegt das geschlechliche Fortpflanzungsvermögen der Mischlinge von der Norm abzuweichen; je ferner die Stammformen einander stehen, um so mehr zeigt sich durchschnittlich die Fruchtbarkeit der Mischlinge geschwächt."

Increased or total sterility is brought about in various ways, as for example, there may be no pollen and no good seeds produced, or there may be a smaller amount of either than in the pure parents. Focke says that no peculiarity of hybrids has attracted so much attention as the lessening of the power of sexual reproduction, and it has been pointed out how important this fact was formerly supposed to be in its relation to the limits of species and varieties. Darwin (*l. c.* 2: 218) says that "the sterility of distinct species * * * and that of their hybrid offspring, graduates, by an almost infinite number of steps, from zero * * * up to complete fertility." Focke (*l. c.* 477) gives genera or families that illustrate the variation of plants as regards the fertility of their hybrid offspring. The hybrids of *Papaver*, *Viola*, *Verbascum* and *Digitalis* are slightly fruitful; those of *Anemone*, *Nicotiana*, *Mentha*, *Crinum*, the Cucurbitaceae and the Passifloraceae are often so; while in the following there are more fruitful than unfruitful hybrids: *Aquilegia*, *Dianthus*, *Pelargonium*, *Geum*, *Epilobium*, *Fuchsia*, *Cotyledon*, *Begonia*, *Cirsium*, *Erica*, *Rhododendron*, *Calceolaria*, *Quercus*, *Salix*, *Gladiolus*, *Hippeastrum*, the Gesneriaceae and the Orchidaceae. While the crosses between distinct species produce hybrid progeny that are variable as regards the quality of fertility, it seems that nearly all hybrids from plants more distantly related are wholly sterile. As an example of fertile bigeneric hybrids, however, the well-known Aegilops wheat may be cited; but this rule is apparently invariable as regards the few that have parents from different families.

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* Focke, Die Pflanzen-Mischlinge, 489. 1881.

When the abnormal condition of the male reproductive organs causes sterility, as is likely to be the case, this infertility may be brought about by a variety of structural causes. The anthers may contain pollen but dehiscence may not take place to allow the pollen means of escaping, or pollen may be entirely wanting. In speaking of this question Focke (*l. c.* 478) says that "in andern Fällen besteht der Blüthenstaub aus kleinen pulverigen bei Anfeuchtung nicht quellenden Körnern von ungleicher Form und Grösse, denen gewönlich einzelne wohlgebildete keimfähige Pollenzellen beigemischt sind." The conclusion in this case is that the abnormal pollen is the cause of sterility and that the normal only is functional. Also, according to Duchartre * Naudin made the observation that the relative fertility of hybrids was *en rapport* with the number of normal pollen-grains formed in the hybrid.

Another and much less usual cause of sterility is found in the apparent incapacity of the female organs to be fecundated, but in many such cases it may be that there is no morphological defect in the ovule. Such a hybrid may sometimes, or usually, be fruitful if fertilized by another plant of the same strain, or by one of the parents, and it is occasionally fertile when self-fertilized, or when pollinated by a plant of the same sort (*Rubus caesius* x *R. Idaeus*).

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* Duchartre. Ann. Sci. Nat. Bot. IV. 19: 129. 1863.

Besides the forms of sterility that result from imperfect sexual organs an infertile condition may also result from other causes. For instance, in unisexual flowers, the male buds may fall away, as in the Cucurbitaceae and the Bignoniaceae, or in some hybrids, *Pelargonium* and *Digitalis* (*D. lutea* x *D. purpurea tubiflora* Lindl.), the anthers may be so transformed that the flowers are hermaphrodite. Finally, sterility may manifest itself in the reluctance with which hybrids produce flowers, as in those of *Rhododendron*, *Epilobium*, *Cereus* and *Hymenocallis*, but Focke (*l. c.* 477) says that these are rare exceptions, since as a rule hybrids flower earlier and more profusely than pure species.

As to the relation between vegetative vigor and relative fruitfulness of hybrids, Swingle and Webber (*l. c.* 412) say that in some cases "the increase in vegetative vigor secured by crossing distinct species is at the expense of fertility, but this is by no means true in all. Focke says that 'it was formerly thought that the diminished sexual fruitfulness is compensated by a greater vegetative luxuriance, a statement the untenableness of which, as Gärtner showed, is most plainly demonstrated by the fact that many of the most fruitful crosses (*Datura*, *Mirabilis*) are also distinguished by a most gigantic growth.' On this subject Fritz Müller also says: 'So far as my experience goes, the hybrids which grow the most luxuriantly are generally the most fruitful.'" Although other instances illustrating this principle might be given it will suffice, I think, to mention the remarkable walnut hybrid which Burbank succeeded in producing from the English form and the California one. This was referred to above (page 144). In this hybrid not only is there a great vigor of growth but the fruit is also unusually large and probably very abundant.

There appears to be no relation between the ease of making a cross and the fertility of the resulting form, but as a rule, the nearer the relationship of the parental forms the more readily will they be crossed. Strasburger,* in commenting on this subject, says: "Manche Familien neigen leichter dazu (Solanaceen, Caryophyllaceen, Irideen u. s. w.), andere bilden nur schwierig oder

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* Strasburger, Lehrbuch der Botanik, Ed. 5, 248. 1902.

überhaupt keine Bastarde (Papilionaceen, Coniferen, Urticaceen, Convolvulaceen u. s. w.). Dasselbe abweichende Verhalten findet sich unter verwandten Gattungen und Arten vor. Weinreben, Weiden, *Dianthus*-Arten sind leicht, *Silene*-Arten schwer, die von *Nicotiana*, *Verbascum*, *Geum* leicht, die Arten von *Solanum*, *Linaria*, *Potentilla* dagegen schwer unter einander zu bastardiren. Eine Hybridisirung von nahe verwandten Arten will oft nicht gelingen (z. B. Apfel- und Birnbaum), dagegen lassen sich Pfirsich mit Mandel, ja sogar Species der verschiedenen Gattungen *Lychnis* und *Silene*, *Rhododendron* und *Azalea*, *Aegilops* und *Triticum* kreuzen, je nach ihrer 'sexuellen Affinität.'"

The suggestion of Strasburger that crosses between mosses and ferns cannot take place because of the difference in the chemical nature of the fluids attractive to the spermatozoids of the two forms, may be a fruitful one when applied to other plants that are difficult or impossible to cross. That is, the substance that attracts spermatozoids, or the pollen-tube, may vary with the plant, and instead of attracting may even repel them. So far as I know the course of the pollen-tube in plants that are nearly enough related for crossing, but which refuse to be crossed, has not been traced, and it is possible that here may be found one reason why certain reciprocal crosses will not take place, why nearly related plants may sometimes not be crossed, and also why one sort of pollen is "prepotent" over another sort. That the pollen-tube responds to such stimulus in the course of its wanderings most sensitively is well shown by Lloyd's account[*] of its behavior in *Diodia* and *Richardsonia*. There may be other factors, as Vernon[†] has found that the relative maturity of the sexual elements in some echinoderms is of great importance when the number of successful crosses, and even the effect of each parent on the offspring, are concerned.

While it is perfectly true that only nearly related forms as a rule may be crossed, there are many instances where hybrids have been made whose parents were generically and even more remotely separated. These, as was mentioned above, are usually wholly sterile. A few such hybrids may be mentioned here.

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[*] Lloyd. Mem. Torrey Club, 8: 88. 1902.

[†] Vernon, Hybrid Echinoid Larvae. Proc. Roy. Soc. 63: 228. 1898.

Gladiolus blandus Sol. of the lily family was fertilized with pollen of *Hippeastrum* sp. and seeds were formed that produced four hybrids, all of which were presumably sterile (Focke, *l. c.* 388). The same author says that *Digitalis ambigua* of the Scrophulariaceae was crossed by Campbell with pollen of *Sinningia speciosa* of the Gloxiniaceae, and of the seeds that were formed only one produced a plant, and that one was sterile. The limits for any cross are thus set by related families, but as has already been shown the limits bounded by the fertility of the offspring are much narrower.

STUDIES OF THE SPERMATOGENESIS AND STRUCTURE OF HYBRIDS

A few morphological studies of hybrids have been made which may now be briefly referred to. I shall speak first of the work on the gametogenesis of hybrids.

Juel * studied the spermatogenesis of *Syringa Rothomagensis*, and as a leading result found that the maturation mitoses were irregular and abnormal, although in some respects certain of the mitoses reported by him approach the usual or normal type. The abnormalities in the tetrad formation are classified and summarized by him as follows:

A. In früheren Entwickelungsstadien auftretend:
  1. Verkümmern der Pollenmutterzellen beim Eintritt des Spiremstadiums;
  2. Durchschnürung des Kernes der Pollenmutterzelle im Spiremstadium;

B. Bei der Tetradentheilung auftretend:
  3. Durchschnürung der Kerne;
  4. Erste Kerntheilung indirect, aber in Bezug auf das Verhalten der Chromosomen abnorm;
  5. Achromatische Kernfigur abnorm;
  6. Ein Theil des Chromatins im Cytoplasma zerstreut;

C. An den Tetraden beobachtet:
  7. Ueberzählige Tetraden. Wahrscheinlich aus 2 hervorgegangen.
  8. Ueberschüssige Kerne in den Zellen der Tetrade. Wahrscheinlich aus 6 hervorgegangen.

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* Juel, Beiträge zur Kenntniss der Tetradentheilung. 2. Die Tetradentheilung bei einer hybriden Pflanze. Jahrb. Wiss. Bot. 35: 638. 1900.

I wish to call attention especially to number 6 of the above table, namely, to that form of irregularity in the distribution of the chromosomes by which a portion of them are thrown out of the nucleus, a portion only remaining. The result of this might be, as Juel suggests, that the nucleus of the tetrad would contain chromatin of pure descent, that is, chromatin derived from one and not from both parents.

Guyer * has studied the spermatogenesis of hybrid pigeons and of hybrid cannas and found in both cannas and pigeons similar mitoses; consequently it will be necessary to speak only of the mitoses in the hybrid pigeon. I shall quote direct (*l. c.* 312):

"In the spermatogenesis of hybrid pigeons several abnormalities are manifested. These may be classified conveniently under three heads: (1) abnormalities in the structure of the spermatozoa; (2) abnormalities in mitoses; (3) degeneration of the germinal cells. Abnormalities in the spermatozoan structure were present in sterile hybrids, the most noticeable feature being a varicosity or swelling about the middle of the head. In tracing the development of the spermatozoa, this curious modification was found to be due apparently to a lack of development of the head; the nucleus did not elongate completely as in normal spermatogenesis. Abnormalities in mitosis were marked in both fertile and sterile hybrids. Large numbers of multipolar spindles were present. These were usually of the tripolar type. Occasionally two distinct and separate spindles occurred in one cell. The spermatocytes of the first order were the cells that showed this phenomenon to the greatest extent. In the normal pigeon the chromosomes in the spermatogonia are sixteen in number and in the primary spermatocyte eight. The latter are laid down in rings and each is evidently double. On the spermatogonia of the hybrid there were sixteen chromosomes and in the primary spermatocyte often more than eight. In the latter there may be several of the large double type and a number of smaller rings, or sixteen small ring chromosomes may occur. If sixteen rings were present they were usually located on two separate spindles, eight to each spindle.

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* Guyer, Spermatogenesis in Hybrid Pigeons. Science, II. 11: 248, 312. 1900; Some Notes on Hybridism, Variation and Irregularities in the Division of the Germcell. Science. II. 15: 530. 1902.

Another peculiarity in the mitosis was the frequent inequality in the division of the chromosomes, in some instances only about one fourth of a chromosome going to one pole." At page 248 he concludes that "these peculiarities in chromosome formation may point perhaps to a tendency in the chromatin of each parent species to retain its individuality. If such is the case, then in those cells with two spindles each bearing eight chromosomes, it is evident that after division, some of the new cells will have chromatin from only one of the original parent species, and some from the other. Some of the spermatozoa, therefore, will bear chromatin from only one of these species. It is a well-known fact that the offspring of hybrids are extremely variable, a portion of these variations being usually in the form of reversions to one or the other of the parent species. The possibility presents itself then, that this reversion may be due to the persistence of the chromatin of only one species in one or both of the germ cells. Carrying the conception still further, the other variations in the offspring of hybrids may be due, perhaps, to the varying proportions of the chromatin of each species in the mature germ cells."

And, finally, Metcalf * has studied the spermatogenesis of hybrid *Gladiolus*. He finds a condition analogous to the two-spindle nuclei of hybrid pigeons in all of the pollen-mother-cells of the hybrid, and he also concludes from this that the two groups of chromosomes represent maternal and paternal derivatives respectively. It is not stated whether the hybrid is a fertile one.†

In addition to the cytological studies as above outlined, some work on the structure of hybrids has also been done. This may be summarized in the following paragraphs.

Macfarlane ‡ conducted an extensive series of investigations on the minute anatomy of several hybrids, his main result being that all of the hybrids which he studied were intermediate in structure, even in the details, and his conclusion that the parents share equally in transmitting their respective characters.

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* Metcalf, Certain Problems Relating to the Individuality of Chromosomes. Proc. Neb. Acad. Sci. 7 : 109. N 1901 (read before the Academy, N 1900).

† Metcalf in a private letter assures me that the hybrid *Gladiolus* is fertile.

‡ Macfarlane, The Microscopic Structure of Hybrids. Gard. Chron. III. 7 : 543. 1890; A Comparison of the minute Structure of Plant Hybrids with that of their Parents, and its bearing on biological problems. Trans. Roy. Soc. Edinb. 37^1 : 203. 1892; Observations on Pitchered Insectivorous Plants. Ann. Bot. 7 : 445. 1893; Observations on some Hybrids between *Drosera filiformis* and *D. intermedia*. Contr. Bot. Lab. Univ. Penn. 2 : 87. 1898.

Farmer * studied the structure of *Polypodium Schneideri*, which is a hybrid between *P. aureum* and *P. vulgare*. The hybrid was reproduced by Farmer. The study showed the hybrid was not strictly intermediate either in form or structure.

In the following section of this paper I shall consider the relation of the results of the cytological studies of hybrids as above outlined, as well as of my own to be given later, to the variation of the hybrid race, but I may refer in this place to one or two considerations in connection with the possible bearing of the structural studies on the same topic. It is to be noted that Macfarlane studied only intermediate forms, but on the other hand the fern hybrid of Farmer's investigations was intermediate neither in form nor in structure. These apparently contradictory results raise the very interesting question, are hybrids, whether intermediate in form or not, always so in structure? Or can it be that variation in form is also associated with differences in structure? A careful histological study of hybrids that are clearly not intermediate, as for instance those following Mendel's *Pisum*-type could not fail to give most interesting results. And it may be added that the results from such study might be of importance in determining the hybrid status of the form.

THE RELATION OF THE CYTOLOGICAL TO THE EXPERIMENTAL STUDIES OF HYBRIDS

The task of the cytologist in the study of plant hybrids is primarily that of observing the relation of the manner of formation of the sex-cells to the variation of the hybrid itself, and it should for that reason include the study of hybrids which have yielded definite results from experiment, such forms, for example, as the *Pisum*-type. Owing however to the recentness of the discovery of the Mendelian laws, studies of this character have not been carried on, as far as I know, and conclusions to cover special cases of variation, for instance the *Pisum*-type, must therefore be regarded as tentative merely. Beyond this, general considerations, such as the fertility or infertility of the hybrid and the form of nuclear division in it, may give grounds for interesting and legitimate conclusions. It is of course only these general considerations that I can take up in the present paper.

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* Farmer, On the Structure of a Hybrid Fern. Ann. Bot. 11: 533. 1897.

From the summary of Juel's work on the *Syringa* hybrid it was seen that all of the maturation divisions were more or less abnormal. What may perhaps be considered the nearest approach to the normal division observed in this hybrid was an apparently typical achromatic figure accompanied by many small chromosomes, which were therefore not like those of heterotypic nuclear mitoses, and which did not split in the metaphase. And it is of interest to note that *Syringa* is probably a sterile hybrid.

Turning now to the results of Guyer from the study of fertile hybrid pigeons, we note that he observed both normal and abnormal mitoses, and some mitoses which were not clearly the one or the other. The latter are of particular interest since it is primarily these that he considers a possible basis for the variation of hybrids.* Among the irregularities in the mitoses in fertile birds, which may contribute to variation, is the following. In the dividing nuclei of some secondary spermatocytes two spindles occur, each bearing half the somatic number of small chromosomes.† As previously given, Guyer concludes (1) that the two-spindle condition shows a tendency in the chromatin of each parent to retain its individuality, (2) that by a proper separation and distribution of the chromosomes pure sex-cells would result, and (3) that the union o these might cause reversion. This conclusion appears to hav been drawn before the publication of the Mendelian law.‡

If the form of maturation mitosis just described occurs ge erally in hybrids, and further if the chromatin is separated a distributed as postulated by Guyer, we should evidently not ha to go further in order to discover the kind of mitosis that wo produce in hybrids of the *Pisum*-type "pure" germ-cells — the i portant part of the Mendelian theory.§ There are however one two considerations in this connection which may be worth bringing forward. In the first place the possibility arises that the spores that are formed from two-spindle nuclei in the mother-cells, even if functional, may contain chromatin from both and not from one parent only. To put this idea somewhat more directly, it may be that the failure of the maternal chromatin to unite with the paternal chromatin, which will be spoken of again presently, results not in the purity of the reproductive cells, but quite the contrary, in their being of hybrid nature. This has certain theoretical interest and will be again referred to. In addition to this the results of my own study of the spermatogenesis of hybrid cotton, which will be given in the following section, lead me to believe that the usual form of maturation division in fertile hybrids is quite like that in the pure race (as indeed Guyer also found in fertile pigeon hybrids), and therefore that the variations in the hybrid cotton are not dependent on irregularities in the mitoses, and consequently if irregularities occur it must be shown that the resulting spores are functional. (The possible exception to this will be given below.)

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* Guyer. Science, II. 11 : 248. 1900.

† Compare Metcalf on hybrid *Gladiolus*, *l. c.*

‡ In his most recent paper (see footnote on p. 155) which was received after was written, Guyer considers it possible that "pure" reproductive cells may be de from normal mitoses.

§ Bateson and Saunders, *l. c.* 12: "the essential part of the discovery is tha *germ-cells or gametes produced by cross-bred organisms may in respect of given ch ters be of the pure parental types.*"

Now since all of the hybrids known to be fertile which have thus far been studied have perfectly normal maturation mitoses, in addition to clearly irregular ones, and further since in known sterile forms abnormal divisions only occur, it seems to me that the variations of the hybrids are either wholly independent of those divisions, or that the mitoses are fundamentally unlike what is now believed. Correns * has apparently reached the former conclusion; he does not think that irregularities in the maturation mitoses have any connection with the splitting of the hybrid race.

It now remains to be seen what sort of maturation mitoses there may be (1) which will result in the separation and distribution of the chromatin so that the ultimate sex-cells may have chromatin of pure descent, and (2) which will also appear to be the same as is believed to occur in pure forms, namely, a double longitudinal division of the chromatin segments.

I shall now refer to the account given by Wilson † of the formation of tetrads by conjugation, but more especially to his ac-

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* Correns, Ergebnisse der neusten Bastardforschungen für die Vererbungslehre. Ber. Deuts. Bot. Gesells. 19: 86. 1901.

† Wilson, The Cell, ed. 2. 1900.

count of the early history of the germ-nuclei. In speaking of the latter, Wilson says (*l. c.* 273): "A large number of observers are now agreed that during the growth-period preceding the maturation division, in both sexes, the nucleus of the mother-cell (spermatogonium, oögonium), both in plants and in animals, passes through some changes preparatory to reduction at a very early period. Thus, in the egg the primary chromatin-rods are often present in the very young ovarian eggs, and from their first appearance are already split longitudinally. Häcker made the interesting discovery that in some of the copepods (*Canthocamptus*, *Cyclops*) these double rods could be traced back continuously to a double spireme-thread, following immediately upon the division of the last generation of oögonia, and that *at no period is a true reticulum formed in the germinal vesicle.* In the following year Rückert made a precisely similar discovery in the case of selachians. After division of the last generation of oögonia the daughter-chromosomes do not give rise to a reticulum, but split lengthwise, and persist in this condition throughout the entire growth-period of the egg. Rückert therefore concluded that the germinal vesicle of the selachians is to be regarded as a 'daughter-spireme of the oögonium (*Ur-ei*) grown to enormous dimensions, the chromosomes of which are doubled and arranged in pairs.' In this case their number seems to be at first the somatic number (thirty-six) which is afterward halved by the conjugation of the elements two and two (Rückert), as in *Lumbricus* (Calkins). It is, however, certain that in many cases (insects, copepods) the double rods first appear in the reduced number." In another place (*l. c.* 257), Wilson says: "A considerable number of observers have maintained that reduction may be effected by the union or conjugation of chromosomes previously separate. This view agrees in principle with that of Rückert, Häcker and Vom Rath; for bivalent chromosomes assumed by these authors may be conceived as two conjugated chromosomes." It should be added further that Montgomery * and evidently Guyer as well † consider the conjugating chromosomes to be of unlike parentage. Therefore the heterotype rings of the normal mitoses in pure races of animals are not only of double origin, but they are so organized that the halves of any chromatin loop are of diverse origin, that is, one half is derived from the one and the other half from the other parent. So that in pure races of animals *if the chromatin is of pure descent*, and, further, *if the maternal and paternal chromatin is segregated as a result of the maturation mitoses*, the ultimate sex-cells are also of pure descent, two of any group containing chromatin lineally derived from one parent and two chromatin from the other. I therefore have suggested * that the same organization of the chromatin occurs in fertile hybrids, and that it forms the morphological basis for variation in accord with the Mendelian conception.†

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* Montgomery, A Study of the Chromosomes of the Germ Cells of the Metazoa. Trans. Am. Phil. Soc. 20: 1901.

† Guyer. Science. II. 15: 530. 1902.

The organization of heterotype rings by the conjugation two and two of previously distinct chromosomes appears thus to be fairly well founded, but the purity of the chromosomes as regards descent is, I take it, not so well established, and here may perhaps be sought a cause for variations outside of the *Pisum*-type. But there is also considerable evidence to show that the chromosomes preserve their individuality during the ontogeny, or if the chromosomes do not retain their individualty, at any rate that the chromatin may retain its purity. Wilson (*l. c.* 204) says: "Observations have given the strongest reason to believe that, as far as the chromatin is concerned, a true fusion of the nuclei never takes place during fertilization, and that the paternal and maternal chromatin *may* remain separate and distinct in the later stages of development—possibly throughout life." On page 299 this author treats the matter somewhat more fully and cites the v of Rükert and Häcker on *Cyclops*, and Herla and Zoja on *Asc* Recently Häcker * has confirmed and extended his earlier clusions, and in a recent paper Moenkhaus states that he found that the paternal and the maternal chromatin may re separate and distinct during several cell generations in hy fishes.

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*Cannon, A Cytological Basis for the Mendelian Laws. Bull. Torrey Club, 29: 657. D 1902.

† This conclusion was also independently formed by W. S. Sutton: On the Morphology of the Chromosome Group in *Brachystola magna*. Biol. Bull. 4: 24. D 1902. Guyer has recently advanced a similar conclusion: Hybridism and the Germ-cell. Univ. Cincinnati Bull. No. 21. N 1902.

The hypothesis above given to account for the variation of the hybrid race after the type of Mendel's pea hybrids applies of course to those whose pure parents are separated by one character only, that is, to monohybrids, and does not clearly to polyhybrids, or to those whose pure parents are distinguished by more than one character. If, however, we find that the two-spindle condition obtains in the spore-mother-cells of fertile hybrids to a considerable degree it seems to me that in the combined results of such abnormal with the normal mitoses we may find a structural basis for the essentials of the variations in the more complex types of hybrids.

It has already been stated that the conjugation of the c mosomes occurs in pure races at some stage before the ma tion divisions, and that by the separation of the chromoso provided they are lineally descended from parental chromosc the spores may be of pure descent. Now when in certain hy the conjugation fails to take place a mother-cell with a two-sp nucleus may be formed as Guyer has stated, † and as he shown in the fertile hybrids studied by him. Metcalf also f in hybrid *Gladiolus*, as I have mentioned in summarizing his v chromosomes in two masses as on double spindles in the pc mother-cells and, finally, I have observed a few mother-cel the hybrid cotton which may apparently had double spindles. the cotton, however, this condition was the exception, as w spoken of below.

Phenomena which are probably associated with the ind dence of the germ-nuclei have long been observed in hy These comprise the greater influence of the one than the parent, or, at the other extreme, the equal influence of parents in the hybrid. Between these extremes are many mediates some of which have already been mentioned (page And it seems possible that in some hybrids the germ-nucle equally and independently mold the character of the cell not combine to effect this as in strictly intermediate hybrids. mer,‡ for example, gives an account of a hybrid *Oxalis* in epidermal cells of which *trichomes typical of both parents* m found in a single cell. Other cases illustrating this point also be cited. It will thus be seen that a close study of the ture of a hybrid may be of considerable use in determining the relative independence of the germ-nuclei.

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* Häcker, Ueber die Autonomie der väterlichen und mütterlichen Kern vom Ei bis zu den Fortpflanzungszellen. Anat. Anzeiger, 20: 440–452. 190

† Guyer. Science. II. 15: 530. 1902.

‡ Farmer. Ann. Bot. 11: 542. 1897.

I wish now to turn from the considerations of nuclear divisions and hybrid variations and apply *theoretically* the principle of the purity of the sex-cells to a moss, a fern, and a seed-plant. In doing so I assume, as a matter of course, that the hypothetical hybrids are monohybrids of the *Pisum*-type. The theoretical application is made rather to call attention to what seems to me a very broad and inviting field for research, than to attempt at this time any development of the field myself. Many additional points of view will undoubtedly suggest themselves at once to any botanist.

We shall consider what happens when one sort of a moss is crossed with another sort, when the spores of the hybrid moss develop, and, finally, when the hybrid is inbred.

In the first place when a moss is fertilized by the sperms of a moss of another species, the moss "plant" is not hybridized, since the effect of the foreign fertilization is to be observed only in the *sporogonium*. This applies to the hybrid of the first generation; what happens in the later generations has apparently not been studied or at least recorded. Focke (*l. c.* 427) says that no hybrid sexual moss plants (gametophytes) have been recognized, and he inquires if some of the numerous sterile mosses may not be hybrid. According to the hypothesis of the purity of the spores we should not expect to find hybrid gametophytes in any generation. And in this connection it is certainly interesting to note that there is said to be no hybrid among the liverworts. This again would be the case if the spores from which the liverwort "plant" arises are not hybrid but pure, and we may perhaps make the rule that *it is the sporophyte, and not the gametophyte, which is of hybrid nature.*

Assuming the purity of the spores, when the hybrid is inbred variation of the sporogonia would occur according to the law of Mendel, but not necessarily according to the *Pisum*-type. The variation of the hybrid will depend on the monoecious or dioecious nature of the moss. This will be clear when we examine the formulae for variation of monoecious and of dioecious ferns.

Turning now to the fern hybrids, we shall first consider a monoecious homosporous hybrid, and, finally, a dioecious homosporous hybrid.

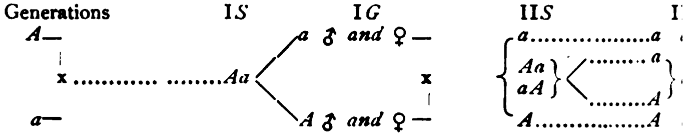

Fig. 2. Hybrid homosporous *monoecious* fern. Explanation. *S*, sporo
G, gametophyte; *A* and *a*, the chromosomes of the two races, when combined
the form is hybrid.

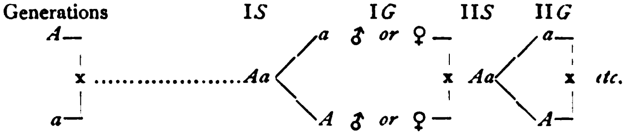

Fig. 3. Hybrid homosporous *dioecious* fern. *Lettered as the preceding fi*

In contrasting the two formulae for fern hybrids as
several points may be worth speaking of. In the first plac
fern hybrids with monoecious prothallia revert after the *P*
type of Mendel; and secondly the hybrids with dioecious s
generations are always some form of intermediate, and
revert. Dioecious forms also, such as *Equisetum* hybrids,
gest problems of interest not necessarily closely connected
their hybridity. Among these the following may be menti
Dioecious ferns viewed from the standpoint of the purity
spores, and hence of the sex cells, give suggestions as t
morphological basis of the origin of heterospory. Coulter *
"The evolution of heterospory seems simple enough. The pl
logical differentiation of the spores was complete when prot
became persistently dioecious. * * * A prothallium producing
sex organs equally well may be regarded as in a state of equili
an equilibrium which is disturbed by any conditions which
the production of one sex organ rather than the other, i
case probably nutritive conditions. This disturbance of the
librium of a bisexual prothallium would certainly find an expr
first in a dioecious tendency, and finally in a dioecious habit.
the habit once fixed the morphological differentiation of
becomes inevitable, since the nutritive requirements of th
prothallia are so different. The evolution of heterospory se
be one of the simplest of selective processes, with inequali
nutrition to furnish the variations."

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* Coulter. Bot. Gaz. 26 : 163. 1898.

I would suggest that the transmission of a *dioecious tendency* is morphologically possible because the spores that give rise to the prothallia are pure, and, therefore, we conclude, tend to reproduce the same sort of prothallia as the ones from which they sprang in the preceding generation, and that the *dioecious habit* is likewise only possible by a continuance of the same process through many generations. By referring to Fig. 3, the formula for a dioecious fern hybrid, it is seen first that the gametophytes are of pure descent, and further that the fern is dioecious, so I suggest that the spores A will produce prothallia like those from which the chromatin of their nuclei was derived and, also, that the spores a will give rise to prothallia like a of the pure form, that is, in *dioecious hybrid ferns, or the pure races, the prothallia that arise from A or a will be male or female accordingly as the sexual ancestor of that spore was male or female.* In other words, may not the purity of the spores be the groundwork upon which the selective processes play that bring about the dioecious from the monoecious condition, that deepen the dioecious tendency into a dioecious habit, and, finally, give rise to the morphological condition known as heterospory?

We may now return from this disgression to examine very briefly what happens when seed-plants of different sorts are crossed.

We should note first that the formula commonly given for the hybrid fertilization and variation in seed-plants is somewhat misleading since it does not take account of the sexual generation, which we believe in the monohybrid seed-plants of the *Pisum*-type, if indeed not in all others, is always pure. Secondly, it is the heterosporous condition of the higher plants, in the place of the homosporous monoecious one of the fern mentioned above, that makes possible the formula $(A + A\,;\ A + a\,;\ a + A\,;\ a + a)$ of the hybrid of the *Pisum*-type. Now we may ask, what morphological conditions are prerequisite for the development of this formula? It is clear in order that this end may be reached that the anthers must organize spores with A and spores with a characters and likewise that the ovary must maturate functional spores with A and with a characters. Now as a matter of fact in the higher plants three of the potential macrospores usually degenerate and one only germinates, so that in any ovule one character, and one sort of chromatin, are eliminated from the problem. Therefore the reversion to one or to another of the pure parents might under certain conditions take place. It thus is necessary in o to effect the splitting after the *Pisum*-type that on the aver taking many plants together, an equal number of each sor germ-cells of the same descent shall degenerate, and that a number shall become functional. The variability of the hi plants as regards the development of the macrospores may in a broad way account for certain conceivable modificatior apparent exceptions to the Mendelian law, so that the morpho of the hybrids must needs be studied if the structural basi hybrid variation is to be understood.

We have then sketched what supposedly takes place mosses, ferns and also when seed-plants of the *Pisum*-typ hybridized, and the general and particular conclusions ma summed up thus:

1. In monohybrids of the *Pisum*-type the spores and th mediate spore derivatives are pure as regards the chromatin co of their nuclei. The application of this principle to the *liver* accounts for the apparent lack of hybrids among them, eit the first or in the later generations; applied to the *mosses* counts for the failure to recognize hybrids in the second and generations. In both liverworts and mosses the "plant" (ga phyte) is of pure descent in any generation, and the sporc only are hybrid. This last consideration leads to the gene tion that in *plants of whatever class where hybridity occurs it haps always the sporophyte only which is hybrid.**

2. In the ferns the chromatin may be transmitted fro sexual generation to another in such a manner as to retain it viduality and thus it may tend to reproduce the sort of g phyte from which it descended, and in dioecious forms t also, so that *the purity of the spores forms the background th make the genesis and the evolution of heterospory a morpho possibility.*

It is likely that the study of such hybrids as have sexual and asexual generations would be of advantage s them a morphological analysis of the nature of a hybrid m made, and thus a clearer understanding of the nature of hy in general but particularly the nature of hybridity in such forms as do not have distinct sexual and asexual generations might be obtained, that is, the hybrids among the seed-plants.

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* The possible exceptions to this have already been referred to (page 155

THE SPERMATOGENESIS OF HYBRID COTTON

The cotton hybrid used in this study * was grown from seed obtained by crossing the Sea Island (Constellation brand) with upland (Klondike brand) cotton, *Gossypium Barbadense* × *G. herbaceum*. The crossing was done expressly for this study by Dr. H. J. Webber, of the Department of Agriculture, in the experimental plots near Columbia, South Carolina. Concerning this cross Dr. Webber writes as follows:

"The flowers were emasculated August 22, 1900, and crossed August 23, the resulting boll producing ten seeds; all of the seed of this we sent to you. But 34*a*, which is of the same parentage and crossed at the same time in our plots at Columbia, all proved to be without question hybrids, being very tall and rank and rather unfruitful, showing in practically every character their hybrid nature." He further says that "34*b* is without much question a true hybrid." The seeds from the cross known as 34*b* were sown in pots in the propagating house at the New York Botanical Garden, about July 20, 1901, and the plants that were derived from these seeds were used by me in this study.

The cotton plants, 34*b*, formed buds in October and the first lot for study was put up on the 29th, and after that at intervals of a week or so as often as the buds appeared to be of the proper size. The hybrids appeared to correspond to the description that Dr. Webber gave for the hybrid of the same parentage, 34*a*, and the 34*b* forms were evidently true hybrids. It was evident also that these hybrids were fertile, but to what degree I was unable to determine, since most of the flowers were removed for study.

Before describing the maturation divisions I may anticipate my results by saying that abnormal sex-cells were present in practically all anthers, and, except in the last flowers formed, normal cells as well. The ratio between the two was an inconstant in this regard the cotton is different from the *Gladiolus* hy and agrees with the pigeon and *Canna* hybrids, as will be see referring to the summary given above. I may also say that principal object in making the study was to learn whethe mitoses were different from those in pure races of analo plants, rather than to make an exhaustive study of the divi as such, and for this reason my material was not suitable fo study of the earlier stages, however important that may be.

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*I wish here to acknowledge my obligations to Dr. Webber, who kindly made the crosses for me and always encouraged the work; to Professor Underwood, of Columbia University, for his counsel and assistance, and to the officers of the New York Botanical Garden, especially to Dr. MacDougal, who placed the excellent facilities of the Garden at my disposal.

I shall turn now to the morphological part of the paper. divisions in the normal cells will be spoken of first, and t shall give some account of the various irregularities which be seen in the abnormal mitoses of the hybrid.

The archesporial cells arise by the division of subepid cells and become pollen mother-cells directly, no formati sporogonous tissue occurring. After the two divisions nucleus, the mother-cell undergoes two simultaneous divisi which the tetrads are formed, and these probably become grains in the usual manner, although the later history of th was not learned. The mitoses leading up to the formation tetrads are as usual heterotypic and homotypic, and theref the same as are found in like mitoses of analogous organis

The cytoplasm of the archesporial cells is of a rectic alveolar structure, and this structure is uniform through cytoplasm of the cell. That is, the portion of the cyt which is immediately around the nucleus is not differentiat the portion which is in the more peripheral part, but has a appearance and structure. This primitive, or undifferentiat dition of the cytoplasm is retained in all cells in which di clear division occurs, but on the other hand it may not be o in the normal cells. Thus the structure of the cytoplasm an interesting and reliable check to the observations of t stages of development of the cells.

When those of the archesporial cells which are to deve normal pollen grains become spore mother-cells, the cy withdraws from the cell walls. This retreat of the cytopla also be observed in certain of the abnormal cells, for in those which do not undergo degeneration in the earlie as will be spoken of again in this paper. The withdrawal of the cytoplasm is to be regarded as the normal and regular occurrence in the archesporial cells of cotton, and is not therefore analogous to the condition observed by Juel in *Syringa*[*] where it was an indication of degeneration.

About the time of the formation of the spore mother-cells, and as a regular structural change accompanying it, the cytoplasm of the normal cells shows a marked change in its structure. A zone of dense protoplasm which takes the cytoplasmic stain with avidity, is formed around the nucleus in contact with the nuclear wall. This perinuclear zone is found also in the developing pollen grains of various plants of pure descent.[†] It is seen not only in the cytoplasm of the spore mother-cell, but in the later stages as well, even in the young tetrads as in *Lavatera*.[‡] The structure of the zone appears to be granular, although in some preparations and under comparatively powerful magnification—Zeiss ocular 18, apochromatic oil-immersion 2-mm. objective—it seemed reticular, thus resembling *Larix*.[§] Outside of the perinuclear zone is the main portion of the cytoplasm which is alveolar in structure and in addition to these two sorts of protoplasm a layer of fibrillae midway between the periphery of the cell and the perinuclear zone is also occasionally found in the spore mother-cells. When first observed the fibrillar layer is of a rather loose structure, but in the older cells the fibrillae are closely bound together and form a compact zone.

A similar zone is figured by Mottier for *Lilium*.[||] This filar plasm, like the achromatic figure, takes the gentian-violet with Flemming's triple stain. As a rule the spore-mother cells do not contain this structure, but it is found with great regularity in the cytoplasm of the older cells. The genesis of the fibrillar layer is difficult to account for in the spore mother-cells; in the later stages of development, however, it is formed by the mantle fibers which stray into the cytoplasm from the two poles c spindle.

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[*] Juel, *l. c.* 640.

[†] Lloyd. Mem. Torrey Club, 8: 71. 1902.

[‡] Byxbee. The Development of the Karyokinetic Spindle in the Pollen-Mother-Cells of *Lavatera*. Proc. Calif. Acad. Bot. III, 2: 63. 1900.

[§] Belajeff, Zur Kenntniss der Karyokinese bei den Pflanzen. Flora, 79: 430. 1894.

Mottier, Beiträge zur Kenntniss der Kerntheilung in den Pollenmutterzellen etc. Jahrb. Wiss. Bot. 30: *pl. 3. f. 5.* 1897.

My material was not suitable for the study of the early l of the chromatin of these cells and therefore the account maturation divisions begins with the spore mother-cell a cludes the two maturation mitoses by which the tetra organized.

The first indication of the approaching first division nucleus of the spore mother-cell which was observed w aggregation of the chromatin to one side of the nucleus a formation there of the spireme. Thus synapsis occurs bef mother-cell withdraws from the cell-wall (*f. 1*). The s ribbon loosens and at length its convolutions extend thro the nucleus. At first the spireme has a beaded appeara an uneven outline, but in the older nuclei the contour i more uniform and the structure much more dense. At tl time the spireme increases in its power of absorbing stains ticularly in the later stages the splitting of the spire observed with great clearness.

When the spireme forms segments, the chromatin for a time collects to one side of the nucleus, and in that situa shortening and thickening of the segments takes place. T ments are long and in delicate loops when first clearly m the loops are much twisted and bent in a variety of way ends of the loops are not infrequently connected by delicat plasmic strands, indicating perhaps that the fusion of the chromosomes had not been a complete one (*f. 4*), an may happen that the union of the chromosomes did not ta exactly at their ends but at a greater or less distance fro Usually, however, the loops are entire and symmetrical no hint as to their possible origin or formation. Very fr in the long chromatin loops a longitudinal splitting may which must evidently be regarded as a precocious process to a subsequent separation of the divided portions.

The chromatin loops shorten and thicken to form they in turn by further condensation lose the ring char in the metaphase of the first division this character reap

In any nucleus the loops and the rings are of a uni that is, the two sizes of rings found in the hybrid pigeon * and in some pure forms in plants † were not observed in the cotton.

At the time when the chromatin segments are becoming condensed and have gathered at one side of the nucleus, characteristic changes are also taking place in the structure of the perinuclear zone of cytoplasm. The inner portion of this becomes less dense and is finally replaced by a coarse reticulum of delicate protoplasmic strands. This network unites with the nuclear wall on one side, and joins the more peripheral and unchanged portion of the perinuclear zone on the other. The reticulum is therefore from its genesis wholly of cytoplasmic origin.

While the changes in the perinuclear zone are occurring as above described, certain developmental modifications may also be observed in the nucleus. Until this time the linin of the nucleus has not been noticeable, but now it assumes a more or less granular appearance and stains feebly, and the nuclear wall shows indication of approaching disintegration. Delicate threads of protoplasm run out from it which join, on the outside, the circumnuclear reticulum, and on the inner side, the linin meshwork. Shortly the nuclear wall becomes entirely broken down and a continuous protoplasmic reticulum occupies the entire cell.

The relation of the karyoplasmic reticulum to the perinuclear zone in the formation of the achromatic figure will be spoken of directly, and it may be premised that it is the same as is found in *Cobaea scandens* ‡ and in *Lavatera*, § as well as in other plants, that is the achromatic figure has elements drawn both from the cytoplasm and from the nucleus.

The topographic relations of the cell constituents at this time will be understood by referring to *f. 7.* When such a section is treated with the Flemming triple stain, the perinuclear zone will be colored deep orange, the reticulum within the perinuclear zone will be colored lightly with the gentian-violet, and, finally, the chromatin will of course take the saffranine.

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* Guyer. Science, II. 11 : 248. 1900.

† Strasburger, Histologische Beiträge, 6 : 42. 1900.

‡ Lawson, Some Observations on the Development of the Karyokinetic Spindle in Pollen-Mother-Cells of *Cobaea scandens*. Proc. Calif. Acad. Bot. III. 1 : 169. 1898.

§ Byxbee, *l. c.*

Prior to the breaking down of the nuclear wall the nucl (plasmosome) presents indications of its disintegration. Its cap for absorbing the stains is lessened, it becomes vacuolated, a length disappears. The degeneration of the nucleolus takes *pari passu* with the formation of that portion of the nuclear ulum which is of karyoplasmic origin, and it may, in fact, cont to its building up, just as occurs according to Strasburger in *Fi*

The net-work which arises from the linin of the nucleus, the cytoplasm immediately surrounding it, from the disinte wall, and finally, perhaps, from the nucleolus also, becomes fied so that a confused mass of fibers are formed which mal felted condition characteristic of the earlier stages in the org tion of the multipolar achromatic figure in the higher plants. fibrillae which come from the reticulum become gather groups with the effect that from the felted condition a mul one ensues, and from this at length the bipolar figure is f Several intermediate stages were observed in the transfor just spoken of, such as the one figured (*f.* 8). The cyto cones, which are so prominent a feature in the early st such an achromatic figure as in *Equisetum* † are wholly w in the cotton hybrid. The presence of the perinuclear cytoplasm, as has been pointed out in *Lavatera*,‡ appears hibit the formation of the *Equisetum* type of multipolar fig

When the achromatic figure is completely differentiat poles extend nearly or quite to the periphery of the cell, a relation between the achromatic figure and the ectoplasm same as described by Lloyd § as occurring in *Asperula*. cotton the relation is a variable one, and appears to de the size of the cell, as for instance, in the spindles of the division the poles do not reach to the periphery but term the outer portion of the cytoplasm. The achromatic figu cotton hybrid, as in pure races, is made up of three sorts namely, of the continous fibers, or central cylinder, the co

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[*] Strasburger, Kerntheilung und Befruchtung bei *Fucus*. Jahrb. Wiss 351. 1897.

[†] Osterhout, Ueber Entstehung der karyokinetischen Spindel bei *Equiseti* Wiss. Bot. 30: 159. 1897.

[‡] Byxbee, *l. c.*

[§] Lloyd, *l. c.* 70.

fibers, and the mantle fibers. The continuous fibers and the contractile fibers arise from the intra-zonal network in a manner above described, but the mantle fibers appear last, they are composed wholly of cytoplasmic material, and apparently are not at all concerned with the splitting or separation of the chromosomes. The mantle fibers give rise to the fibrillar layer which was spoken of above and which is a conspicuous element of the cell after the first nuclear division.

The chromosomes become arranged so as to form a plate midway between the poles of the bipolar spindle and at right angles to the spindle. In the metaphase of the first division the chromosomes are usually ring-shaped but vary more or less as in the metaphase of this division in pure races of plants. However, when first arranged in the plate the ring form may not appear, but it does subsequently, during the process of the splitting of the chromosomes. I was not able to determine with certainty whether the first split separated chromosomes which corresponded to the two halves of the heterotype ring, or whether the split followed the second cleavage. If the former occurs, then according to the hypothesis advanced in the preceding part of this paper, the daughter nuclei are pure as regards the chromatin content. If, however, the latter is the case, the nuclei of the daughter cells would be of mixed descent. The tetrads in either case * would contain chromatin which had descended in a linear manner from either and not both of the parents.

In the anaphases of this division the chromosomes are U-shaped, V-shaped or X-shaped as in pure forms. The second longitudinal splitting which was observed in the prophases, could not be clearly made out in the anaphases because the chromosomes were so small and dense. By repeated counting of the chromosomes, I determined that there was an equal distribution of them in the first mitosis: the reduced number was 28.

In late anaphase the chromosomes take a position at some distance from the poles, so that when the reconstruction begins the ends of the spindle extend beyond (*f. 12*).

Certain characteristics of the achromatic figure may be mentioned in this place. The mantle fibers extend from the poles, at a sharp angle to the spindle, well into the cytoplasm, and n up the fibrillar layer which is so conspicuous in the cells. Tl of the fibers that are in the immediate neighborhood of the dat ter nuclei soon lose the filar appearance, become structur and the chromosomes in early telophase lie freely in an appare homogeneous substance.

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* It is conceivable, however, that a *different orientation* of the heterotype rings might give other results.

The reconstructed nuclei possess a distinct nuclear wall chromatin forms a coarse reticulum (*f. 12*) and the nucleol reconstructed. The steps in the reformation of the daug nuclei were not closely observed but appeared roughly to c spond to the reverse of the breaking down of the mother nuc

When the daughter nuclei are fully reconstituted the fibe the achromatic figure may still be seen in the inter-nuclear c plasm; they persist during the division of the nuclei and even be observed in the cytoplasm of the young tetrad. The pres of these spindle-fibers in normal mitoses, and the total absen them in abnormal ones, form a reliable basis for judging wh the mitosis was normal or abnormal, but this of course w probably not be true if the divisions were so nearly norm some described by Juel, Guyer and Metcalf. Such, howeve not to be found in the cotton hybrid.

The daughter nuclei are so small that it is difficult to stu all closely the sequence of changes which lead up to and ac pany their division, and, therefore, I contented myself with ob ing certain definitive phases only.

Continuous, contractile and mantle fibers are of course pr in the achromatic figure, but the latter do not eventually fo fibrillar layer in the cytoplasm as the mantle fibers of the pr ing division do. The continuous fibers persist and may be along with those from the first division in the young tetrad.

In the prophases of this division the chromatin masses ar themselves in a nuclear plate as in the former division, but is a distinct difference between the chromatin of the first and c second mitosis. In the prophases of the second mitosis the mosomes are of a uniform size and appearance and are rod-sh I was not able to make out the presence of the second and cocious split which in some forms may be observed at this In the metaphase each chromosome divides into two equal tions, and these go to the opposite poles of the spindle and there build the tetrad-nucleus.

Although in many regards the description of the mitoses just given must be considered as a meager one, I think that enough has been said to show that they are the exact homologues of these nuclear divisions in pure races of plants. That is, in the cotton hybrid the first maturation is a heterotypic one and the second is homotypic.

My material was not of sufficient amount or kind to permit me to study the subsequent nuclear division of the tetrad, or the germination of the spore.

The division of the cell does not take place until the daughter nuclei are formed and completely reconstructed. When the division occurs the planes of division are at a sharp angle with one another and pass between the daughter nuclei, and the result is an equal apportionment of the cytoplasm among the four nuclei of the group. Indentations appear in the periphery of the cytoplasm and midway between the nuclei, which deepen into constrictions, and finally accomplish the separation of the nuclei and the formation of the tetrads.

A cell-wall is not organized until the tetrads are built and the formation of the wall takes place as follows: colorless accretions appear on the periphery of the tetrad; later a delicate membrane may be distinguished connecting them. Both the thickened portions and the membrane are evidently produced by secretion and respond to the test for cellulose. Somewhat later the spore-wall becomes relatively thick by the addition of the cuticularized exine; the places where the cellulose accretions first appear mark the location of the germinal pores.

Abnormal Nuclear Divisions. — The foregoing account of the tetrad formation in hybrid cotton is based on the study of anthers which were among the first to be put up, namely October 29, and were taken from the form known as "34*b*." A study of material collected in November and December showed that most of the male cells were perfectly normal. The flowers gathered in January were unfortunately older, and did not therefore show the division stages, but the appearance of the cytoplasm as well as of the nuclei was such as to indicate that normal mitoses had taken place. In all of the material, however, which was gathered in the season, and which had nuclei in the process of divisi the time of putting up amitosis occurred. I have not been satisfactorily to determine whether these abnormal divisions due to the cultural conditions, to the fact that the plant v hybrid, or to both these factors with the added one that the flc were the last to form on the plants.

A sharp distinction was made in the cotton between the r of the abnormal cells which accomplished division, and those were abnormal but degenerate and never underwent division by the direct or by a modification of the indirect method. generation of the sex cells, either of the archesporium or in stages, could be found to some extent in practically all of th terial examined, but this was always so well marked structı that no confusion arose by which the degeneration of the cell questioned.

When the degeneration took place in the archesporial c was very noticeable both in the nucleus and the cytoplasm. cytoplasm assumed various conditions and structures. It coarse reticulum of rather delicate meshes which had a ur appearance as if the microsomes were wanting, or a large va occupied the center of the cell, pushing the nucleus to on and causing the cytoplasm to gather in various parts of th The cytoplasm of the degenerate cells takes stains with avidity. This is especially to be noticed in the anthers tha both normal and degenerate nuclei. When in such anthe cytoplasm of the normal cells is properly stained that c degenerate cells will always be badly overstained. This i different from the staining capacity of cells whose nuclei div the direct method, since these cells stain in a perfectly r manner.

The nuclei of degenerate archesporial cells are often s than those of the normal cells in the same anther, the n membrane is frequently very pronounced, and the chromc are of the size and number of the somatic ones. I found cells which were preparing for the first division and which h two-spindle condition observed by others in hybrids; but I c notice any such nuclei in later stages, since these cells dege before the divisions are completed. It is possible that the same plants grown under other conditions might have carried the divisions farther. Besides the irregularities in division as just given, others, especially in the achromatic figure, were also noted; in some cells the multipolar spindle was seen accompanied by many small nuclei.

Another form of irregularity occurred which is not so clearly degenerate but which must also be considered a factor that leads to infertility, namely the direct nuclear divisions in cells gathered the later portion of the winter. The mother-cells of the nuclei which were to undergo direct division were apparently like their counterparts in which normal mitosis would occur except as regards the structure of the cytoplasm, which retains its primitive condition; that is, a perinuclear zone is not differentiated, and a fibrillar layer is not present. The process of amitosis consists of a division of the nucleolus, followed by an equal or an unequal direct division of the remainder of the nucleus such that a nucleolus goes to each daughter nucleus.

The first amitotic nuclear division is usually equal, and the result of the division resembles that brought about by the indirect method, and also the second division may be equal and thus a tetrad group in appearance, much like that normally organized, may be formed. Usually, however, the divisions are not equal and small nuclei are associated in the same cell-complex with larger ones. The extreme is to be seen when the nucleus of the mother-cell fragments and the cytoplasm contains numerous small nuclei. Some of the forms of direct division are shown by figures *17*, *18* and *19*.

Cell-division may or may not follow the direct nuclear divisions. If it does, tetrads which are like the normal ones except as to the presence of small nodes will be formed; if, however, cell division does not take place, monstrous pollen grains result. Since the tetrads formed as a result of direct division may be like those organized in the regular manner a mere macroscopic examination of the mature pollen will give no indication of the genesis of such, and hence, it may be supposed, of its ability to germinate.

By way of general summary, I may say that in the anthers of the hybrid cotton one finds both normal and abnormal conditions.

The first maturation division in the normal cells is he
the second homotypic; and also amitosis occurs. M
tional abnormalities in the nuclei were observed; such nu
ever, do not undergo division, but degenerate in the ar
cell or some later stage, in every case before the first
Among such irregularities a few mother-cell nuclei were
with two spindles and the somatic number of chromosom

COLUMBIA UNIVERSITY, 1902.

Explanation of Plates

PLATE 7

FIG. 1. Microspore mother-cell.

FIG. 2. Same.

FIG. 3. Split spireme in prophase of first division.

FIG. 4. *a*, *b*, *c*, *d*, *e*; typical chromatin loops from the prophases division, showing the double splitting.

FIG. 5. Same at a later stage.

FIG. 6. Condensation of rings into chromosomes preparatory for the sion; breaking down of the nuclear wall.

FIG. 7. Same, later stage.

FIG. 8. A multipolar spindle which is becoming a bipolar one.

FIG. 9. Metaphase of the first division.

FIG. 10. Anaphase of the same division, somewhat to one side of t line; in the section next to this one the poles of the spindle were observed quite to the periphery of the cell.

PLATE 8

FIG. 11. Chromosomes in the metaphase of the first division.

FIG. 12, *a*. Resting daughter-nucleus. *b*. Sketch of same nucleus, fro section, showing its relation to the spindle, and that of the latter to the p the cell.

FIG. 13. Daughter-nuclei; the reticular character of the cytoplasm shown; the presence of inter-nuclear fibrillae, the remains of the continuou indicated.

FIG. 14. Early anaphase of second division; the more heavily shad of the cytoplasm indicates the position of the perinuclear zone; the fibrilla the cytoplasm is shown.

FIG. 15. Metaphase of the second division.

FIGS. 16–19 are of abnormal (amitotic) nuclear division of spore mother

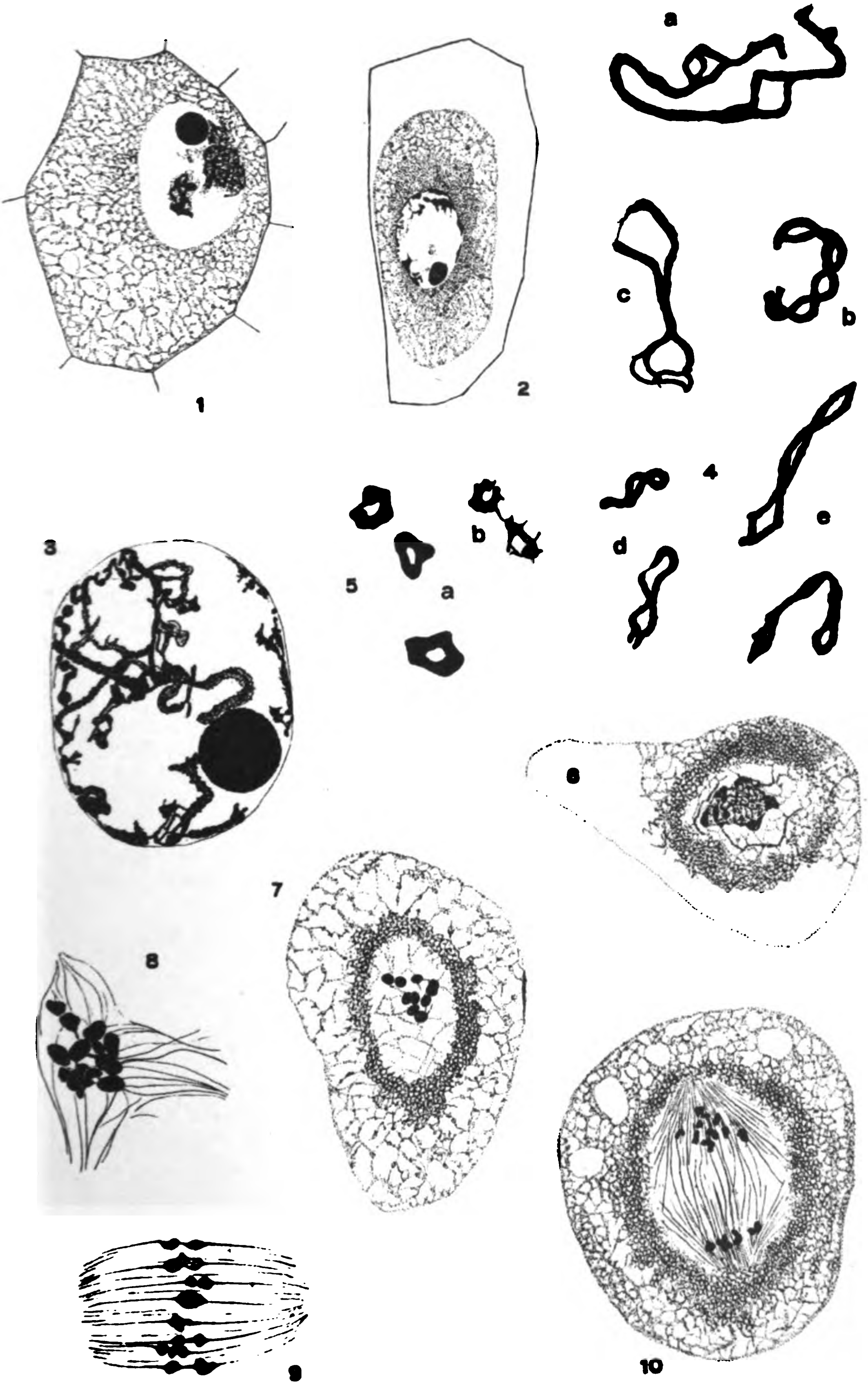
FIG. 16. Daughter-nuclei.

FIG. 17. Nuclei of different sizes.

FIG. 18, *a* and *b*. Tetrads with smaller nuclei scattered in the cytoplasm.

FIG. 19, *a* and *b*. Equal and unequal direct division of the nucleus of th cell.

NOTE. — The primitive character of the cytoplasm is shown in Figs. 16 and 18*b*.



SPERMATOGENESIS OF HYBRID COTTON.

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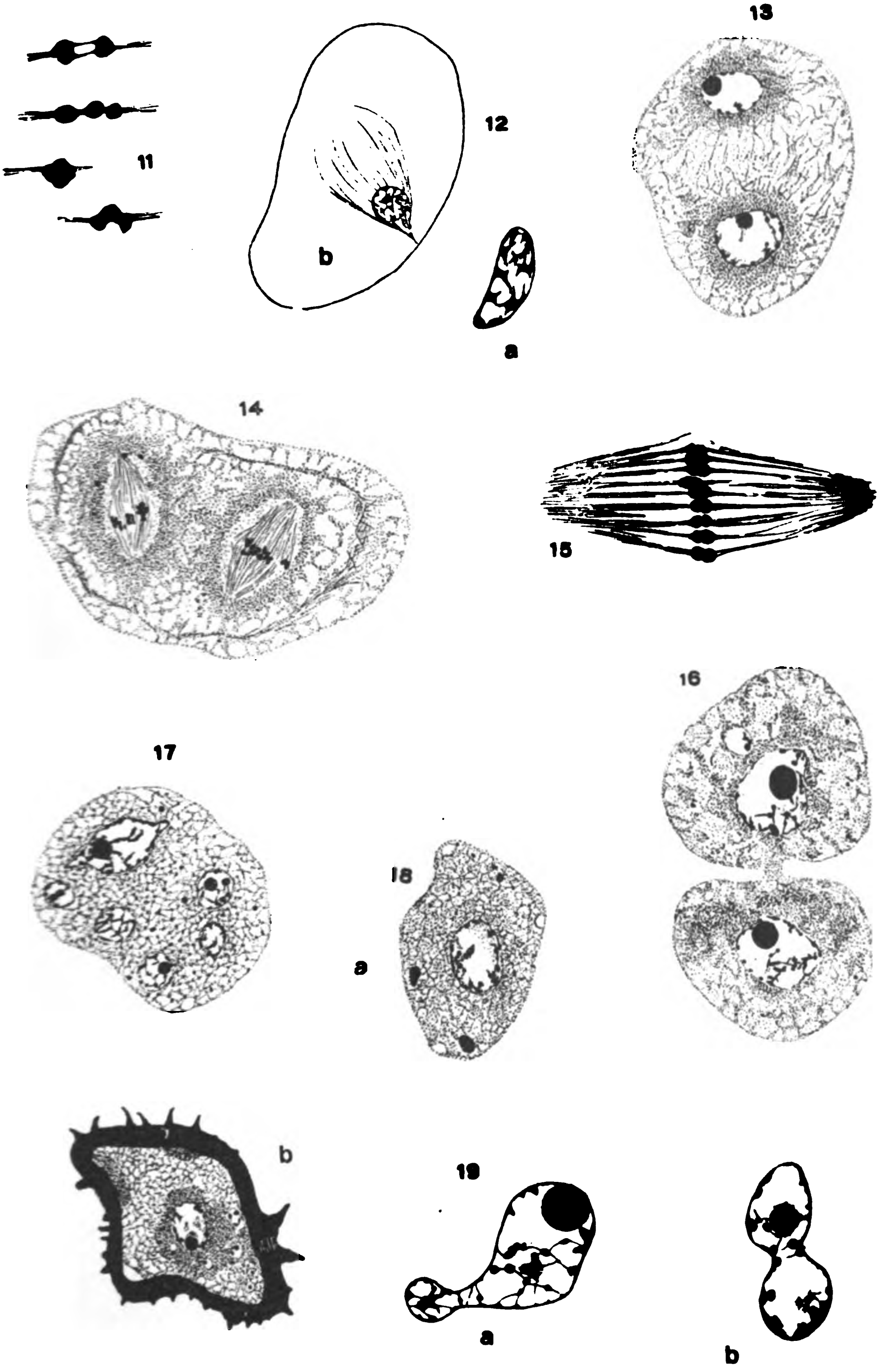

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LUCIEN M. UNDERWOOD,
Professor of Botany.

COLUMBIA UNIVERSITY,
NEW YORK CITY.

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OF COLUMBIA UNIVERSITY--No. 203

BOTANICAL EXPLORATIONS IN GEORGIA DURING THE SUMMER OF 1901—II

NOTEWORTHY SPECIES

By ROLAND M. HARPER

NEW YORK
1903

[Reprinted from the BULLETIN OF THE TORREY BOTANICAL CLUB, 30: 319–342. Jun

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Botanical Explorations in Georgia during the Summer of 1901.— I. Itinerary

By Roland M. Harper

My work on the flora of Georgia in 1901 was chiefly confined to the coastal plain, where more interesting botanical problems seem to be encountered than in any other part of the state. I entered the state at Savannah on the 4th of June, and on the morning of the same day went up to Millen, 78 miles northwest of Savannah, on the line between Burke and Screven counties, and about a mile east of the Ogeechee River, which here forms the northern boundary of Emanuel County. On the 5th I made two trips to the river (nos. 756–801),* exploring the swamps on both sides of it.

On the following day I went to the northern part of Bulloch County for a few weeks' stay at the home of a friend. Soon after crossing the Ogeechee River the pine-barrens (which are almost wanting in the vicinity of Millen), with their characteristic flora, made their appearance. At Graymont, in Emanuel County, where I left the railroad, I stopped to do a little collecting (nos. 803–820) before proceeding to my destination.

From the 7th to the 18th I was occupied in making the acquaintance of the plants of Bulloch County, collecting during this time several species of more than ordinary interest (nos. 821–916). The flora (making allowance for the difference in season) and the topography of northern Bulloch County were found quite similar to those of that part of Coffee County visited in September, 1900.

The floral areas of northern Bulloch County fall quite readily into the following five principal classes : sand-hills, dry, rather dry, and wet pine-barrens, and swamps (the last being perhaps capable of some subdivision). Each intergrades more or less with those next to it, but it is rare for any one species to be found in more than two of them. Some genera, however, have representatives in all. This is notably the case with *Rhynchospora*, which seems to be one of the largest genera of spermatophytes in this part the state. The pine-barren ponds which are so characteristic some parts of southwest Georgia are rare or wanting here.

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* These numbers refer to the plants collected.

Bulloch County is of interest historically as having been in probability at one time the home of Mr. John Abbot, who has skilfully portrayed a number of the interesting plants of Georg in his "Natural History of the rarer Lepidopterous Insects Georgia," published in 1797. Having examined this work a fe weeks previously, I noticed on coming to Bulloch County tl large number of plants growing in the vicinity which had bee

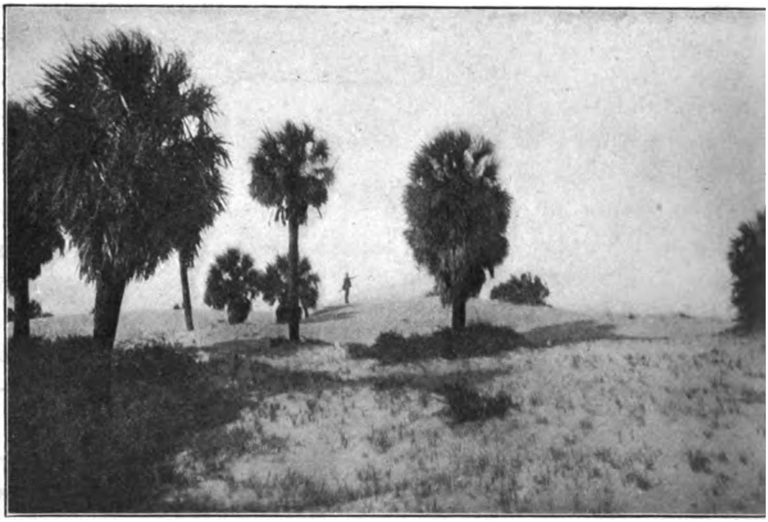

FIG. 1. Scene on the dunes of Tybee Island, showing *Sabal Palmetto*. June 21.

figured by Mr. Abbot, a larger proportion than I had ever see elsewhere; and I collected several of them in order to throw mor light on those which had never been definitely identified.

On June 19 I went down to Savannah to spend a few days i that vicinity. On the 20th I collected (nos. 917–922) near Guytor in Effingham County, thirty miles from Savannah, and on the 21s (nos. 923–933) on Tybee Island, at the mouth of the Savannal River. In Savannah I was joined by my brother, Otto T. Harper who accompanied me most of the time during the rest of th summer, and assisted me with some of the work.

On the 22d I was back in Effingham County, and in the afternoon walked from Guyton to Springfield, the county seat, about six miles back from the railroad (nos. 934–938). The pine-barrens around Guyton differ from those farther inland in being more level and full of shrubs, mostly *Ilex glabra*, with some *Xolisma ferruginea* and two or three small species of *Quercus*. In the vicinity of Springfield, however, a marked difference is to be noted. About half way from Guyton to Springfield the country becomes rather hilly, and the pine-barrens disappear, giving way to shady deciduous woods sheltering many species of more northern distribution. This feature continues the rest of the way to Springfield and probably some distance beyond. Springfield is on the divide between the Ogeechee and Savannah rivers, and must be considerably higher than Guyton, which is near the Ogeechee and only about seventy-five feet above sea-level.

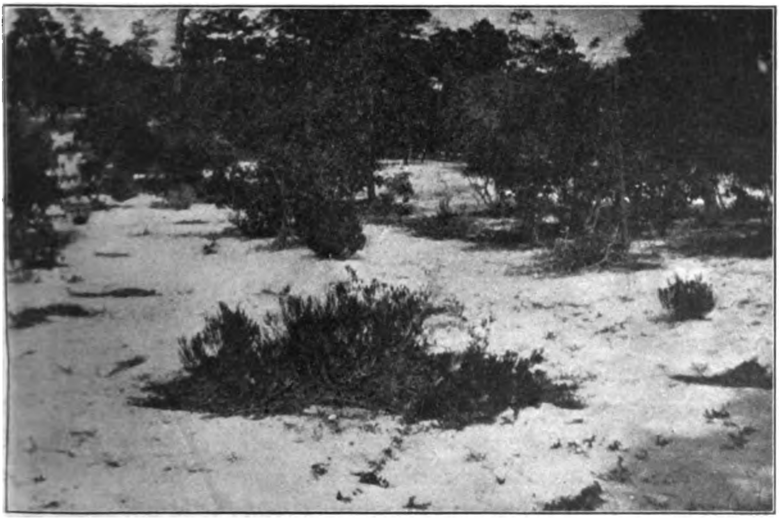

FIG. 2. Rosemary sand-hills, Emanuel County, Georgia. "Rosemary" (*Ceratiola ericoides*) in the foreground. June 28.

On June 24 I returned to Bulloch County, by way of Dover, Statesboro and Pulaski, collecting a few plants (nos. 939–943) at the latter place before starting across the country to my destination. For the next ten days I continued my studies of the flora of

Bulloch County, with most interesting results. During the first fe days of my stay there I had heard some mention of a "Rosema Church," several miles away, and on asking my friends if it did n derive its name from some plant, I was answered in the affirmati and was given an interesting description of the place, but it w not until June 28 that I had an opportunity to visit it. Rosema Church is situated on the left bank of Fifteen Mile Creek, Emanuel County, among sand-hills of quite a different type fro those seen elsewhere. The sand here is whiter than that of t ordinary sand-hills, and is said to be deeper, but as far as know at present it is of the same Columbia formation. *Ceratic ericoides*, the "rosemary," from which the place takes its nam is the most characteristic plant. The flora is not so rich as th of the ordinary sand-hills, but is composed mostly of differe species, some of which will be mentioned in the latter part of th paper. The absence of grasses is a noteworthy feature. The rosemary sand-hills doubtless represent the extreme of xerophy conditions in this region. My numbers 975–984 were secured this trip to this rosemary sand-hills in Emanuel County, a numbers 944–974 and 985–988 were collected in Bulloch duri the remainder of my stay there.

This eastern portion of the coastal plain of Georgia was qu familiar ground to Bartram, Michaux, Elliott, Baldwin, Beyrich a other early botanists, but has been considerably neglected sin their time. After seeing many of the species of these authors their type regions I found that I was able to understand the much better than before. This kind of study is much more sat factory in many cases than any amount of examination of ty specimens, too many of which are poorly preserved or acco panied by insufficient data.

On the morning of July 3 I left Bulloch County and dro over to Graymont on my way to the southwestern part of t state, stopping there again to collect a few plants (nos. 989–99 At Stillmore I also had a few hours to wait, and collected the numbers 994–996. During the afternoon I proceeded to Colli in Tattnall County, where I remained until the next morning (n 997–1002). Collins seems to be in the same belt of flat count as Waycross, though it is considerably higher (235 feet above s level). The rolling country appears again immediately west of Collins, however.

On the 4th I resumed my journey, and after traveling almost due west for 126 miles, mostly through rolling pine-barrens, stopped at Leslie, in Sumter County, where I had spent some time the previous year, though later in the season. My brother had preceded me there by several days. We made Leslie our headquarters until the latter part of August, in the meanwhile making several trips of greater or less extent to various places south and west of there. Within easy walking distance of Leslie, in the counties of Sumter, Lee and Dooly, I collected numbers 1003–1017, 1025–1082 and 1102–1126 in July and 1241–1247 in August. Numbers 1018–1024 and 1127–1146 were collected in and near Americus in July.

On July 17 we started on a journey to the Chattahoochee River, about seventy miles west, passing through the counties of Webster and Stewart, and into the terrane of the Cretaceous formations, corresponding to the "Central Prairie Region" of Alabama. The prairie feature seems to be lacking in Georgia, however, this region being more hilly than any other portion of the coastal plain of the state, some of the hills rising to a height of about 700 feet above sea-level. As far as I am aware, nothing has ever been published on the flora of this Cretaceous region of Georgia, beyond a few references by Bartram, who passed through the upper part of it in the summer of 1776, and described the natural features of the country in his "Travels," published several years later. Unfortunately a large proportion of this region is now under cultivation or has been otherwise tampered with, making the study of its natural floral conditions rather difficult, and in our short stay I did not have time to wander far from the highways of travel in order to study the more primitive conditions.

On the morning of the 18th I collected numbers 1083–1087 at Lumpkin and Union in Stewart County during the stops of our train. That afternoon we stopped at Omaha, the last station on the Georgia side of the river, and walked down the river a few miles (nos. 1088–1094). The most interesting plants were found immediately on the banks of the river, which are here about sixty feet high and very steep, and are covered with a dense growth of trees, of great variety and often of magnificent proportions, interspersed with cane-brakes of *Arundinaria gigantea* twenty or twenty-five feet tall. *Taxodium distichum* is here conspicuous by its absence, whether because of the steepness of the banks, or for some other reason, I do not know. These banks are so high that they are never overflowed, consequently there are no "bottom lands" along the river here.

At the time and place of our visit to the Chattahoochee River about ten feet of Cretaceous rocks were exposed at the base of the bank, rising perpendicularly from the water's edge, the rest of the bank being composed of the Columbia sands. Very few flowering plants grow on these rocks, which are difficult of access on account of their perpendicularity, but numerous springs issuing from the bank along the line of contact of the two formations supply moisture for many mosses and liverworts.

Early the next morning we visited an interesting pond (the only one seen in the Cretaceous region) in the woods south of Omaha (nos. 1095–1099). Later in the day we went up the left bank of the river a few miles (nos. 1100, 1101), then turned away from the river and walked east as far as Louvale. On the morning of the 20th we walked to Lumpkin, and from there took the next train back to Leslie. Between the river and Louvale I did not stop to do any collecting, but made many notes on the flora of the Cretaceous uplands. The flora of this region, at least in Stewart County, seems to be mostly a mixture of that of the Tertiary region nearer the coast and the metamorphic region on the north, with few if any endemic species. The abundance of *Arundinaria* is one peculiar feature, however, as in the corresponding portion of Alabama. The Cretaceous region of Georgia is doubtless analogous to the "tension zone" of New Jersey (described by Dr. Hollick*), which is also Cretaceous.

Our next trip outside of Sumter County was on the first three days of August, to Adams, in Lee County, midway between Americus and Albany. While traveling southward from Americus I was interested to see the same succession of topographic and floral zones that I was already familiar with between Americus and the Flint River to the eastward. These zones, which seem to correspond with certain geological formations, here run in a general northeasterly and southwesterly direction.

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*Am. Nat. 33: 1-14, 109-116. 1899.

On the train I met a former acquaintance, whose home was in Baker County, and after I had explained to him the object of my travels he mentioned that the cane (doubtless *Arundinaria gigantea*) had flowered in the vicinity of his home that spring, an occurrence which had never before been known to the oldest inhabitants. This corresponds with the observations of Dr. Mohr in Alabama, published on the preceding day.*

Adams is evidently in the same pine-barren zone as Leslie, but around Adams the Lafayette formation is mostly overlaid by the Columbia, which makes some difference in the flora. We remained in the vicinity until the 3d, during that time crossing Kinchafoonee Creek on the west and Muckalee on the east (nos. 1147–1162). On the east side of Muckalee Creek, some eight or ten miles southeast of Adams, are some interesting lime-sinks, a few of which were visited on the afternoon of the 2d. On the return trip to Leslie the next day, which was made partly on foot, I collected *Plantago sparsiflora* (no. 1163) near Smithville in Lee County and an apparently undescribed species of *Mesadenia* (no. 1164) a few miles south of Leslie in Sumter County.

The following week we started on a more extensive trip to the extreme southwestern part of the state, by way of Americus and Albany. Our first stop on this trip was at Camilla, in Mitchell County, on the 7th and 8th (nos. 1165–1170). The most interesting natural feature in the vicinity of Camilla is the "Slough," which is shown on most maps of Georgia, though I have never yet seen it mentioned otherwise. It is represented on the maps as a body of water about twenty miles long and one or two miles wide, approximately parallel to the Flint River in Mitchell and Decatur counties. But it is not a body of water at all, nor even a swamp. That portion of it which we explored, a mile or two west of Camilla, is simply a broad shallow depression about a mile wide and perhaps ten feet lower than the surrounding country. At the time of our visit there was considerable water in it as a result of recent rains (August being one of the wettest months in that part of the country), but it is said to be ordinarily quite dry for its whole length, except in a few holes which are deep enough to hold water throughout the year. The flora of the Slough is not very remarkable. The principal woody plants in it are medium-sized bushes of *Quercus Virginiana*, *Crataegus aestivalis*, and *Diospyros Virginiana*, with *Pinus palustris* in drier places. Among the herbaceous species in the Slough may be mentioned *Sporobolus Floridanus*, *Acerates Floridana*, *Breweria aquatica*, *Diodia teres*, *Chrysopsis graminifolia* and *Rudbeckia Mohrii*. This is very much the same kind of flora as is found around the mayhaw (*Crataegus aestivalis*) ponds of Sumter County. *Nama ovata*, conspicuous with its large bright blue flowers, was the only species found in the Slough which I had not seen elsewhere.

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*Contr. U. S. Nat. Herb. 6: 103, 389. 1901.

On the 8th we continued our journey as far as Thomasville. The next day was occupied with a trip to the type locality of *Nymphaea orbiculata*, about six miles northeast of the city (nos. 1171–1181). On the 10th we traveled west 21 miles, to Whigham, in Decatur County, in the midst of a topographically and botanically remarkable region. The surrounding country is quite hilly, much more so than that a few miles to the northward, and the forests are composed almost entirely of deciduous trees. Although less than sixty miles from the Gulf of Mexico, one standing in these deciduous forests could easily imagine himself among the mountains 250 miles farther north. Similar conditions prevail near Thomasville, though perhaps not in such marked degree; also at Tallahassee, Florida (which is about thirty miles from Whigham), according to the reports of geologists and botanists who have been there.*

Five or six miles north of Whigham these densely wooded hills terminate and the comparatively level pine-barrens of the Lower Oligocene or lime-sink region are again seen. About seven miles from Whigham is one of the most remarkable lime-sinks in the state. It is known to some geologists as Forest Falls, but the inhabitants of that region call it simply the "Lime Sink." There is a full-page illustration of it with description in Bulletin No. 5 of the Georgia Geological Survey. This lime-sink differs from all others which I have seen in its great depth (about ninety feet) and in containing a waterfall eighty feet high, making it one of the most beautiful natural features in South Georgia. I know of no other such waterfall in the entire coastal plain of the eastern United States. The side of the sink opposite the falls is not too steep to allow of an easy descent to the bottom, and we spent a couple of hours at this interesting spot on the morning of August 12 (nos. 1190–1194).

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* See Nash, Bull. Torrey Club, 23: 96. 1896.

On leaving Forest Falls we walked southwestward toward Bainbridge about nine miles (nos. 1195–1201), to visit a pond which is also illustrated in the bulletin just mentioned. There it is called Fairview Lake, but we found "Open Pond" to be the name in current use in the vicinity. This pond is about half a mile in diameter, and takes its name from the fact that, unlike most of the ponds of the coastal plain, there is no vegetation showing above its surface except a few bushes near the shore. The water is unusually clear, and the shore is sandy, affording a habitat for several very interesting plants (nos. 1202–1206). In all these respects it resembles very much some of the ponds of New England.

Early the next morning we explored another pond about the size of Open Pond and two miles north of it, of which we had been told on the previous day. This latter is known as "Cane Water Pond," and is said to derive its name from the abundance in it of maiden-cane (*Panicum digitarioides*). It is very different from Open Pond, being surrounded by cypress (*Taxodium imbricarium*) swamps and filled with a luxuriant aquatic vegetation. Here we had the use of a boat, so were able to explore the pond somewhat thoroughly (nos. 1208–1213). Cane Water Pond is remarkable for containing a representative of each of our five North American genera of Nymphaeaceae, viz., *Cabomba*, *Brasenia*, *Nelumbo*, *Nymphaea* and *Castalia*. The *Brasenia* and *Nelumbo* are of course the same species as found in the northern states, but the other three genera are represented by different forms which will be mentioned later. The *Nelumbo* is quite rare, but the other four are abundant and their floating leaves together with those of *Limnanthemum aquaticum* serve to cover the surface of the pond very densely, leaving only two or three open spaces a few yards across. Another interesting feature of Cane Water Pond is the presence in it of several floating islands, composed principally of *Triadenum*

Virginicum, *Ludwigia sphaerocarpa*, *Ludwigiantha arcuata*, *Cephalanthus occidentalis*, and a small species of *Eleocharis*. The *Cephalanthus* is probably attached to the bottom, but the other species have no direct connection with the soil.

Around both Cane Water and Open Ponds, and all the way between them, the soil is of the Columbia sands, loose and dry, giving rise to a flora not unlike that of the sand-hills of southeast Georgia. In such situations numbers 1214 and 1215 were collected.

From Cane Water Pond we retraced our steps to Open Pond followed the road from there toward Bainbridge about two miles and then went back to Whigham by a different road. Soon afte turning back toward Whigham we passed a limited area of ver dry white sand, similar to that of the rosemary sand-hills of Eman uel County and containing a few of their characteristic specie which were not seen elsewhere in southwest Georgia (nos. 121 1217).

From Whigham I went alone on August 14 to Saffold, in t southwestern corner of Early County, on the Chattahoochee Riv and collected along and near the river that afternoon and the ne morning (nos. 1218–1232). The banks of the Chattahoochee this point, about thirty miles from its confluence with the Fl and a hundred feet above sea level, are only about half as high they are near Omaha, but still quite steep. As they are here s ject to occasional overflow the flora is rather different from t farther up. *Rhus copallina*, *Aralia spinosa* and *Bumelia lycioi* species which elsewhere are usually shrubs, here become tr arborescent. Specimens of *Aralia* with trunks six inches in di eter and twenty-five feet tall and of *Bumelia* eight inches thick about fifty feet tall were observed.

There are several small lime-sinks between the station and river, though this is very near the inland edge of the lime- region. A short distance north of the station is a rather rem able feature for this part of the state, a steep rocky wooded hill sloping toward the river, with of course a rather peculiar f The outcropping rocks, which are very hard and siliceous, clothed with mosses and lichens, and *Asplenium platyneuron* g in their crevices, just as it does in the mountainous parts of state. Among the flowering plants inhabiting this hillside are *Dioscorea*, *Hydrangea quercifolia*, *Cercis*, *Phaseolus polystachyus*, *Erythrina herbacea*, *Viola villosa*, *Yeatesia*, *Polymnia Uvedalia* and *Melanthera hastata*. Some fragments of the rock from this place have been identified by means of their fossils as Lower Oligocene.

About noon on the 15th I went back thirty miles over the same route I had come the day before, to West Bainbridge, where I collected numbers 1233–1238 in the Columbia sands along the Flint River, and during the afternoon I traveled forty miles northward on the Georgia Pine Railway through Miller and Early Counties to Arlington, in Calhoun County (nos. 1239, 1240). Arlington seems to be in the same pine-barren zone as Leslie, but on account of a heavy rain the next morning I was not able to study carefully the similarity of the floras. On the afternoon of the 16th I continued my journey to Albany, where I had a few hours to wait, so I went out across the Flint River to have a look at the flora and geological features, but did no collecting because this locality had been already pretty well explored by Dr. Chapman, Dr. Small and other botanists.

From Bainbridge, at the coastward edge of the lime-sink region, to Sumter County, at its inland edge, the flora of the banks of the Flint River does not seem to vary much, and all the species seen at Albany were the same as those already seen elsewhere. From Albany I went to Cordele, crossing the Flint River at still another place, where it forms the boundary between Lee and Worth Counties, and returned to Leslie the morning of August 17.

Ten days later I started for the metamorphic region, going by way of Richland and Columbus. At the latter place I crossed the Chattahoochee River to examine some of the geological features of the fall-line (the inland boundary of the coastal plain). On the morning of August 28 I left the coastal plain and went up to Woodbury, in Meriwether County, near the Flint River, 51 miles from Columbus, where I stopped two days (nos. 1249–1273).

The most noteworthy natural feature in the vicinity of Woodbury is the range of Pine Mountains, which extends approximately east and west through the counties of Harris, Meriwether, Talbot and Upson. These are the southernmost mountains in the eastern

United States, but they are rarely shown on maps and are very little known outside of their immediate vicinity. The only measurement of their altitude which I can find was made some years ago over G. M. & G. R. R. tunnel thirteen miles below Woodbury, and is 1,148 feet. This range passes within two or three miles of Woodbury, where the Flint River cuts through it in a narrow gap or gorge about 400 feet deep. Most of my collecting among the Pine Mountains was done in the vicinity of this gap, in Meriwether and Upson Counties. The mountains are very steep, especially in the vicinity of the river, where they rise abruptly from the water's edge with a slope of about 45°. The rock of which they are composed is a hard sandstone, which gives rise on disintegration to a very sandy soil, supporting a flora which is quite different from that of eastern Middle Georgia and resembles in many ways that of the coastal plain.

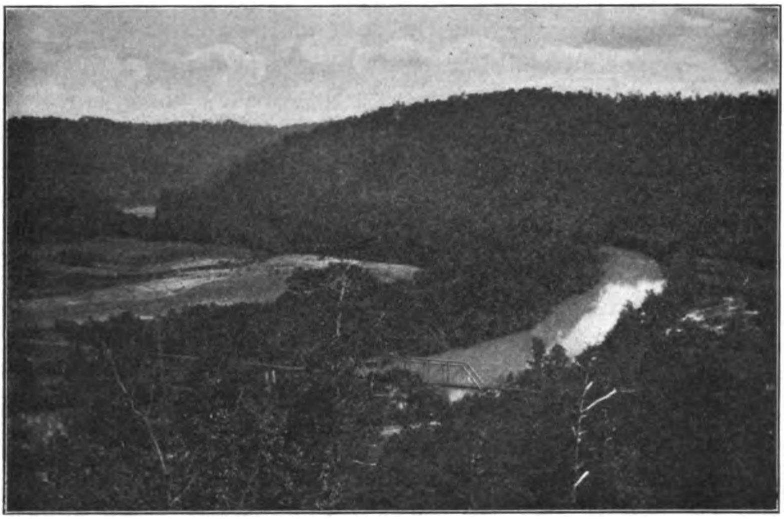

FIG. 3. Pine Mountains near Woodbury, showing gap of Flint River; looking southeastward from an isolated peak near the river. Aug. 29.

These mountains take their name from *Pinus palustris*, which is abundant all over them, often attaining as large dimensions as in the pine-barrens of South Georgia. Its occurrence here is not mentioned in even the most recent publications of the state agricultural department, and was therefore entirely unexpected. I heard of a few sawmills in operation among these mountains, but saw little evidence of their work. The flora of the dry southern slopes of the mountains is not unlike that of some of the dry pine-barrens 100 miles farther south, being characterized by such species as *Andropogon furcatus*, *Paspalum bifidum*, *Cyperus retrofractus*, *Yucca filamentosa*, *Agave Virginica*, *Quercus Catesbaei*, *Ceanothus Americanus*, *Crotalaria rotundifolia*, *Indigofera Caroliniana*, *Cracca Virginiana*, *Stylosanthes biflora*, *Vaccinium arboreum*, *Asclepias verticillata*, *Vernonia angustifolia* and *Chrysopsis graminifolia*. On the shaded northern slopes however many Alleghanian species are met with, such as *Dryopteris Noveboracensis*, *Uvularia perfoliata*, *Polygonatum biflorum*, *Trillium stylosum*, *Quercus rubra*, *Castanea dentata*, *Magnolia Fraseri*, *Heuchera Americana*, *Robinia Pseudacacia* and *Antennaria solitaria*. Along the banks of the river at the base of the mountains two species which are usually confined to the swamps of the coastal plain, *Nyssa uniflora* and *Cyrilla racemiflora*, are quite common at 650 feet altitude, the latter sometimes growing on rocky cliffs with *Kalmia latifolia*. The former extends up the river to Pike County.

Near Woodbury, at about 775 feet altitude, are some bogs with a flora much like that of similar places around Americus, containing such lowland species as *Lycopodium pinnatum*, *Cyperus Haspan*, *Eleocharis tuberculosa*, *Rhynchospora axillaris*, *Juncus trigonocarpus*, *Polygala cruciata*, *Rhexia Virginica*, *Eryngium virgatum*, *Gratiola pilosa* and others which will be mentioned later. On the 29th I went over into Pike County a few miles, and collected a few plants in a similar bog at about the same altitude, which contained besides some of the species just mentioned *Scleria trichopoda*, *Rhexia ciliosa*, *Cynoctonum sessilifolium*, *Viburnum nudum*, *Eupatorium verbenaefolium* and *E. rotundifolium*.

On the 30th I proceeded to Griffin, twenty-nine miles farther, noticing on the way that *Pinus palustris* extended up into Spalding County to within a few miles of Griffin. One species was collected in the woods near the Experiment Station that afternoon.

The next day I went by way of McDonough up to Atlanta, where I rejoined my brother. On September 3, we were at College Park, making collections in that vicinity, in the southern edge of Fulton County and adjacent portions of Campbell (nos. 1275–

1283). Two days later we went up to Dalton, from which point we made only one excursion before leaving the state, collecting numbers 1284–1292 on the Oostanaula Shale about two miles east of the city.

The number of days which I spent in Georgia in 1901 was the same as in the previous year, and although not so many specimens were collected, more was accomplished in other ways. My travels by rail within the state covered about 1,380 miles, and as about 98 per cent. of this distance was traversed in the daytime, I was able to make observations on the flora of nearly every mile traversed. I collected in twenty-four counties, and made notes on the flora of seventeen others. Over 100 photographs illustrating my observations were taken.

Among the noteworthy results of my trip may be mentioned the re-discovery of *Elliottia racemosa*,* the finding of inexhaustible quantities of *Isoetes* in the coastal plain of Georgia, where none had been known to exist before, and the exploration of the sandhills of southeast Georgia, the Cretaceous region, the Slough, Forest Falls, the ponds of Decatur County, and the Pine Mountains.

Dr. Mohr's "Plant Life of Alabama," which appeared during the summer, was a great help to me in several ways, giving me an opportunity to compare the floral conditions in Georgia with those of the corresponding portions of Alabama; and it was a source of considerable satisfaction to note how nearly his treatment coincided with that which I had already planned for Georgia.

Some of the undescribed or otherwise noteworthy plants collected on this trip will be discussed in the concluding portion of this paper.

COLLEGE POINT, N. Y.

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*See Plant World, 5: 87–90. *pl. 12.* My 1902; also Sargent, Silva N. Am. 14: 31. 1902.

Botanical Explorations in Georgia during the Summer of 1901.— II. Noteworthy Species

By Roland M. Harper

Unless otherwise noted, the plants mentioned below were collected on my expedition of 1901, the itinerary of which was described in the last number of the BULLETIN.

ADIANTUM CAPILLUS-VENERIS L.

Although this interesting fern has not yet been reported from Georgia by any other botanist, it is quite widely distributed in the lime-sink region. Last summer [*] I found it quite adundant in Dooly County (no. 1064) not far from where I first discovered it several years ago, also in the central part of Lee County (no. 1161), and in all the lime-sinks visited in Decatur County, especially at Forest Falls (no. 1193). The illustration of this waterfall in the geological bulletin already mentioned led me to suspect very strongly the occurrence of the *Adiantum* there, and evidence in support of this suspicion accumulated as I drew near the place. In Camilla I was told that "a maidenhair fern, different from the one in the mountains," grew at Forest Falls, and in Thomasville the next day I saw specimens of it in cultivation which were said to have been obtained there. On the inaccessible perpendicular side of the sink, within reach of the spray of the waterfall, it grows most luxuriantly.

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[*] As this paper was mostly prepared in the spring of 1902, such phrases as this of course refer to 1901.

[The preceding number of the BULLETIN, Vol. 30, No. 5, for May, 1903 (30: 271–318, *pl. 13, 14*), was issued 16 My 1903.]

ADIANTUM HISPIDULUM Sw. Syn. Fil. 124. 1806

Collected in an apparently unused well in the outskirts Thomasville, where it was accompanied by *Woodwardia areola* on the morning of August 9 (no. 1171). As far as I know, tl Old World species has never been reported as growing spc taneously in the United States. It was fairly abundant and fru ing copiously, and seemed as much at home as the *Woodwara* which is a common inhabitant of wells in South Georgia.*

ISOETES FLACCIDA Shuttl.

This species (or some forms of it) is represented in my 1 collection by five numbers, all from the coastal plain, though species of *Isoetes* had previously been reported from the coa plain of the southeastern United States outside of Florida.

Numbers 843 and 951, partly emersed, were collected June in a sluggish pine-barren stream in Bulloch County, and 1112 was found in a similar situation in Sumter County, July It is not absolutely certain that these three numbers represent typical *I. flaccida*, which grows in "lakes and clear streams, mi and west Florida," and is said † to mature in April and May disappear in June.

Number 1010 is a plant of rather different habit and ha It was found in wet pine-barrens around a mayhaw (*Crat aestivalis*) pond in Sumter County, and was a smaller and plant than the others. It grows in the greatest abundance, t concealed by the tall grass that one might walk over it day day without suspecting its presence. I only discovered it dentally by pulling up a specimen with another plant, b getting down on my knees I found it in apparently inexhau quantities. At that time, July 5, there was more water in pine-barrens than I ever saw before or after, and yet none *Isoetes* was completely submersed, so it is almost a strict restrial plant. The principal species accompanying it were *taria* sp., *Eleocharis tricostata*, *Rhynchospora Tracyi*, *Rhexi tosa*, *Sabbatia campanulata*, *Breweria aquatica*, *Gerardia h*

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* On a subsequent visit (Sept. 18, 1902) the *Adiantum* was found to be ishing.

† Engelm. Trans. Acad. Sci. St. Louis, 4: 386. 1882.

Helenium sp., and *Rudbeckia Mohrii.* I did not revisit the locality until August 22, at which time the *Isoetes* seemed to have completely disappeared, but a careful search revealed its dead and withered leaves lying flat on the moist ground, and the ripe sporangia buried just below the surface.

Number 1046, collected on July 11 around a cypress (*Taxodium imbricarium*) pond near Cobb in the same county, had much the same appearance, though differing slightly in habitat. These two numbers last mentioned are referred by Mr. A. A. Eaton, who has examined some of my specimens, to *I. flaccida rigida* Engelm. (Trans. Acad. Sci. St. Louis, **4**: 386. 1882), which he considers merely a later emersed state of *I. flaccida.* There are some discrepancies between my specimens and the original description of this variety, as regards season and habitat, but these may perhaps be due only to the difference in latitude, the original specimens having come from south Florida.

The above observations on *Isoetes* are mentioned chiefly to show the great necessity for further field work on the southern species, and to indicate that the genus may be found much more abundant in the Southern States than at present supposed.

SAGITTARIA ISOETIFORMIS J. G. Smith, Rep. Mo. Bot. Gard. **6**: 115. *pl. 53.* 1895

This interesting little plant was collected on the muddy margin of a small pine-barren pond in Decatur County, between Forest Falls and Bainbridge, August 12 (no. 1198), where it was accompanied by *Eleocharis tricostata*, and it was seen a few hours later in and around Open Pond, in the same county. It seems to have been known hitherto only from peninsular Florida.

The specific name is a most appropriate one, doubtless more so than its author realized. The submersed sterile form grows in great abundance in the shallow clear water of Open Pond near the shore, just as *S. graminea* does in New England, and it is here impossible to distinguish it from *Isoetes* without close examination.

CYPERUS RETROFRACTUS (L.) Torr.

While walking along the summit of the Pine Mountain range in Meriwether County, on the 29th of August, I noticed for the first time that this species has an adaptation for dissemination l animal agencies. After passing through a patch of it I fou many of the spikelets adhering to my clothes by their sha points. I do not know whether any other species of the gen behaves in the same way, but not many of them have the reflex spikelets which are an essential feature of this mode of disse ination.

CYPERUS IRIA L.

This introduced species was found rather common in cultiva fields in the Chattahoochee River bottoms in Early Cour August 14 (no. 1224). Not previously reported from Geor Florida or Alabama, though there can be little doubt that it gr also on the other side of the river in the other two states.

Scirpus fontinalis sp. nov.

Culms tufted, 12–18 dm. long, triangular at least below, summits very slender and nodding. Basal leaves few, 3–4 long by 3–5 mm. wide; stem-leaves few or several, ascendin almost appressed, slender and acute: umbels compound, unec rayed, axillary and terminal, the 1–4 lateral ones on slender flatt drooping peduncles 1–3 dm. long: spikelets (often partly t formed into tufts of leaves) all on slender pedicels, 2–3 mm. t oblong when young, their axes elongating as the lower scales off and becoming finally about 1 cm. long: scales oblong, concave, 1.5 mm. long, with scarious whitish margins and keels: bristles 6, smooth, tortuous, about as long as the ac achene light brown, oblong, triquetrous, 1 mm. long, acute a ends, covered with minute depressed conical papillae, and with the short slender base of the style.

This species is somewhat intermediate between *S. divaricat* and *S. lineatus* Michx., but is abundantly distinct from eith resembles the latter (which has not yet been reported from G in having axillary umbels, but differs in most of its essentia acters, such as its smaller spikelets and pointless green scal others more difficult to describe. From *S. divaricatus* it is distinguished by its slender nodding culms, ascending leav internodes and long-peduncled axillary umbels, as well a thicker spikelets and papillose mucronate achenes, and habitat. *S. divaricatus* is a stouter usually erect plant, v merous widely spreading or deflexed leaves and a singl terminal umbel, generally inhabiting muddy swamps of creeks and rivers. It too is often proliferous late in the season, but the tufts of leaves spring from the nodes oftener than from the inflorescence. (This character is well shown in my no. 1142, collected in the swamp of Muckalee Creek above Americus, July 30.) In all the specimens of *S. divaricatus* examined I have observed no deviation from a strictly terminal umbel, while in the species under consideration every specimen I saw had at least one lateral one.

The specimens of *Scirpus fontinalis* were collected in the shallow margin of a shaded pool of clear cool water issuing from a spring within the corporate limits of Leslie, Sumter County, on the afternoon of July 6 (no. 1012). It was accompanied by *Cyperus strigosus*, *Scirpus Eriophorum*, *Rhynchospora miliacea*, *Juncus setaceus*, *Polygonum setaceum*, *Samolus floribundus*, and other semi-aquatic plants. The temperature of the water was taken the same afternoon and the next morning, in different parts of the pool and at various depths, and was found to be in every case 68° Fahrenheit. It probably does not vary much from this point throughout the year. A fragment of fossiliferous rock from the hillside just above the spring was sent to the U. S. Geological Survey and identified as being probably of the Zeuglodon horizon (uppermost Eocene). The chemical composition of this rock has not been determined, but the water issuing from it is reputed to be limestone water.

ELEOCHARIS ROBBINSII Oakes

On July 13 I found in the northern part of Lee County a pine-barren pond perhaps ten acres in extent and two feet deep in the middle, almost filled with this species (no. 1068), growing so luxuriantly as to conceal the water. This seems to be the only station reported for it between Delaware and Florida. The only other plants seen in the deeper parts of the pond were *Homalocenchrus hexandrus* and a few small *Cephalanthus* bushes. Around the margins of the pond were observed among other things *Sporobolus compressus*, *Rhynchospora fusca*, *R. Tracyi*, *Scleria gracilis*, *Polygala ramosa*, *Stillingia aquatica*, *Rhexia aristosa* and *Boltonia diffusa*, some of which have an equally remarkable distribution.

RHYNCHOSPORA FUSCA (L.) Ait. f.

Collected on the sandy margin of a pine-barren pond in the northern part of Lee County (as just mentioned) July 13 (no. 1067). This species has apparently been reported but once before from the Southern States. Mr. M. L. Fernald * mentions its having been collected by A. H. Curtiss, at Milton, Santa Rosa County, Florida (no. 5929, July 8, 1897). The specimen under this number in the U. S. National Herbarium looks very much like mine, but the one at the New York Botanical Garden has a somewhat different appearance and may not represent the same species. I have more recently discovered that Mr. Nash's no. 1321, from the sandy shore of Lake Juana, Lake Co., Florida, July, 1894, distributed as *R. gracilenta*, is also *R. fusca*, at least the representation of it in the U. S. National and Columbia University herbaria; and Mr. Fernald informs me that the material in the Gray Herbarium is the same. These southern specimens differ from northern and European ones in being a little more slender, but otherwise seem to be identical.

RHYNCHOSPORA DODECANDRA Baldw.

Collected on the rosemary sand-hills of Emanuel County, where it is one of the most characteristic species, June 28 (no. 977); also in very dry white sand about two miles from Open Pond, Decatur County, August 13 (no. 1216), where it was associated with *Paronychia riparia*, *Dicerandra linearifolia*, *Serenoa* and *Stipulicida*. It does not seem to have been reported from Georgia before, or so far inland, these two stations being about sixty miles from the coast.

MAYACA FLUVIATILIS Aubl.

Mr. Fernald has recently reported † the collection of this South American species by Mr. Curtiss last year in Florida. It is represented in my 1901 collection by no. 1179, from a cypress pond in Thomas County, August 9. There are some differences between this species and *M. Aubleti* which Mr. Fernald failed to mention. The leaves of *M. fluviatilis* are much longer and more acute, exceeding the peduncles, and the capsule is oblong instead of globose. My specimens were completely submersed, while *M. Aubleti* usually grows in sandy bogs rather than in ponds. I have not been able to detect any essential difference in the finely sculptured seeds, however.

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* Bot. Gaz. 24: 433. D 1897.

† Bot. Gaz. 33: 154. 21 F 1902.

On August 12 I saw what was probably the same plant in Decatur County, but did not collect it. There are quite a number of specimens referable to this species in the U. S. National Herbarium and that of Columbia University, mostly from Florida.

XYRIS SMALLIANA Nash, Bull. Torrey Club, **22**: 159. 1895

Collected on the morning of July 19 (no. 1096) in a shallow pond in the woods south of Omaha, Stewart County, where it was abundant, and accompanied by *Panicum digitarioides*, *Scirpus cylindricus* (no. 1095), *Pontederia cordata*, *Castalia odorata* (no. 1097), *Brasenia purpurea*, *Limnanthemum aquaticum*, *Monniera Caroliniana*, *Utricularia purpurea* and other interesting plants. Previously reported only from the type-locality in Florida.

Xyris scabrifolia sp. nov.

Plants solitary, grayish green. Roots fibrous: stem with a slightly bulbous base 6–8 mm. in diameter, enveloped in the pale striate membranous sheaths of the leaves: leaves 1–3, usually 2, erect, acute, slightly twisted, 3–4 dm. long, about 3 mm. wide at the middle, tapering below (about 1.5 mm. wide just above the sheath), the whole surface of the blade minutely transversely rugose; uppermost sheath 12–15 cm. long, very obliquely truncate, acute: scape 5–7 dm. tall, 1–2 mm. in diameter, terete except for a minute longitudinal ridge on one side, pale and rugose like the leaves: head oblong, about 12 mm. long and 8 mm. thick at maturity: scales oblong, entire, the largest 7–8 mm. long: lateral sepals lanceolate, about 3 mm. long, the narrow wing of the keel lacerate above the middle: corolla yellow.

This species seems nearest to *X. Caroliniana* Walt., but differs from that and all other species known to me in the rugose, almost scabrous, surface of its leaves and scapes. This peculiar rugosity makes it as rough to the touch as some species of *Equisetum*, such as *E. laevigatum*. It differs further from *X. Caroliniana* in its terete scape and pale sheaths. It is a very slender plant, resembling in this respect *X. flexuosa* Muhl. (especially southern specimens of that species).

My specimens were collected on August 28 in an open bog near Woodbury, Meriwether County, at about 775 feet altitude (no. 1254). They were accompanied by an interesting association of plants, most of them coastal plain types, such as *Lycopodium pinnatum* (no. 1255), *Eleocharis tuberculosa*, *Rhynchospora axillaris*, *Juncus trigonocarpus* (no. 1253), *Polygala cruciata* (no. 1257), *Eryngium virgatum* (no. 1252) and *Gratiola pilosa*. This locality is about 25 miles from the nearest part of the coastal plain.

Before this time apparently only two or three of our North American species of *Xyris*, namely, *X. flexuosa*, *X. montana* and perhaps *X. Caroliniana*, had been known outside of the Atlantic coastal plain, and it is noteworthy that in these three species *X. scabrifolia* finds its nearest relatives.

Dr. Engelmann, in Plantae Lindheimerianae,* described a variety *scabra* of *X. Caroliniana*, but his plant is now treated as identical with *X. flexuosa*, and his description shows that it is quite different from my plant.

In Dr. Mohr's herbarium (now deposited in the U. S. National Museum) there is a specimen which is doubtless my *X. scabrifolia*, mounted on the same sheet with two specimens of *X. flexuosa* collected near Mobile, July 14, 1883.

JUNCUS MEGACEPHALUS M. A. Curtis

Collected in low grounds just back of the sand-dunes on Tybee Island, June 21 (no. 925), where it was accompanied by *J. aristulatus* (no. 926) and several other plants mostly maritime; also in a moist shaded sandy place among the lime-sinks east of Muckalee Creek in Lee County, August 2 (no. 1159), with *Cyperus cylindrostachys*, *Dichromena colorata* (no. 1157) and one or two other species which I had previously seen only along the coast.

The differences between this long-neglected species and its relatives were well pointed out by Mr. Coville † several years ago, and my specimens agree perfectly with his description; they have also been examined by him and compared with authentic specimens. I do not find that this species has been reported from

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* Boston Jour. Nat. Hist. 5: 235. 1845.

† Bull. Torrey Club, 22: 302–305. 1895.

Georgia before. It seems always to indicate the absence of the Lafayette formation.

JUNCUS DIFFUSISSIMUS Buckley

On July 3 I found a most luxuriant growth of this species (no. 995), in a marshy place near Stillmore, Emanuel County, thus extending its known range about 150 miles farther eastward than the station reported by me * last year. Associated with it were *Panicum scabriusculum*, *Sagittaria Mohrii* (no. 994), *Eleocharis tuberculosa*, *Juncus Elliottii*, *J. polycephalus*, *J. trigonocarpus*, *Sarracenia rubra*, *Rhus Vernix* and other species of more or less interest, the *Sagittaria* being also considerably farther east than it had been reported before.

IRIS VERNA L.

This species, usually in the southeastern states an inhabitant of dry pine-barrens, was collected on August 29 on the northern slopes of the Pine Mountains in Meriwether County, at about 800 feet altitude (no. 1266), and seen five days later and 200 feet higher in dry woods in Campbell County, but without traces of flower or fruit at either locality.

As noted by Dr. Small † a few years ago, the leaves of this species become considerably elongated in summer, but he failed to mention the interesting fact that although equitant, they are decidedly dorsiventral, being bright green on one side and glaucous on the other. They spread out like a fan and bend away from the rootstock (which is perpendicular to the plane of the leaves), in this way bringing the green side uppermost.

GYMNADENIOPSIS NIVEA (Nutt.) Rydb.

Habenaria nivea (Nutt.) Spreng.

Collected in the pine-barrens of Bulloch County, June 15 and 26 (nos. 892, 954). One of the specimens of the latter number was the largest I ever saw, being nearly 6 dm. tall, with about sixty flowers in the spike. The object of mentioning this species here, however, is to note that the flowers are plainly 5-ranked in the spike, as may be readily ascertained by looking at a living plant endwise. I have never seen this character mentioned before, and do not know how many species share it, but it is certainly not the case with all orchids, or even with all spicate ones, as for instance in *Gyrostachys*, different species of which have the flowers in one, three or four ranks.

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* Bull. Torrey Club, **28** : 469. 1901.

† Bull. Torrey Club, **24** : 175. 1897.

PARONYCHIA HERNIARIOIDES (Michx.) Nutt; Spreng. Syst. 1: 822. 1825*

Collected on the ordinary sand-hills along Big Lott's Creek in Bulloch County, June 17 (no. 912), and on the rosemary sand-hills of Emanuel County, June 28 (no. 978); also seen on July 3 in similar situations in Tattnall and Montgomery Counties, especially along the left bank of the Little Ocmulgee River at the western border of the latter.

This species has usually been described as prostrate, but incorrectly. Young specimens, like no. 912, have much the habit of *Anychia dichotoma*, while fully developed specimens, such as no. 978, have the numerous branches very widely speading, making the plant considerably broader than high, but they seem to be strictly self-supporting, and never show the slightest indication of being prostrate. Such a specimen when pressed has very much the appearance of *Euphorbia cordifolia* Ell., a strictly prostrate plant, and this is doubtless the cause of the error.

Cabomba Caroliniana pulcherrima var. nov.

Stem a meter or more in length, reddish-purple. Submersed leaves similar to those of *C. Caroliniana*, but dark-colored and with narrower segments. Peduncles tortuous. Petals bright purple. Floating leaves, calyx and fruit nearly as in the species.

Although further study may show this to be a distinct species, the differences at present known seem only to entitle it to varietal rank. The purple stem and petals are the most striking features. The latter are of exactly the same color as the corolla of *Utricularia purpurea*, for which species our plant might easily be mistaken a short distance away. I find no mention of a purple-flowered *Cabomba* in botanical literature.

Collected in three or four feet of water in Cane Water Pond,

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* The place of publication of *Paronychia herniarioides* is usually given as Nuttall's Genera, but in that work only the name appears, without synonymy or description.

Decatur County, on the morning of August 13 (no. 1209). The plant was pretty well distributed over the pond, though not in great abundance. The specimens which resemble mine most closely, of all the herbarium material I have examined, were collected by Rugel in 1843 in Lake Jamony (Iamonia) and near Tallahassee, Florida, but their age makes it impossible to tell what the color of their petals might have been. More recent specimens, collected near Tallahassee by N. K. Berg, and preserved in the herbarium of the New York Botanical Garden, show the purple petals quite distinctly, besides resembling mine in general appearance as much as do those of Rugel. Both of these localities are within forty miles of mine.

Castalia odorata latifolia var. nov.

Leaves floating in deep water, orbicular with narrow sinus and acute lobes, 4–6 dm. broad, the veins thick and prominent beneath and copiously anatomosing near the slightly upturned margins; flowers large, the longest petals about 1 dm. long. Otherwise very similar to *C. odorata.* (*Castalia reniformis* Nash: not *Nymphaea reniformis* Walt.)

The identity of Walter's *Nymphaea reniformis* * has long been a puzzle. His description, "foliis reniformibus, corollis polypetalis, loculis monospermis," does not fit any known plant, and Mr. E. G. Baker, of the British Museum, has informed me that there is no specimen of it in Walter's herbarium. Willdenow, Pursh and Elliott took up the species on Walter's authority, apparently without being themselves acquainted with it, Willdenow placing it in *Nelumbium*, probably on account of the phrase "loculis monospermis," which may have been an error. Delessert's figure, probably the only one which pretends to represent the species, shows a flower much like that of *Castalia odorata*, and a leaf with the basal lobes rounded as in *Nymphaea* (*Nuphar*), but with the venation of *Castalia*. If this figure is trustworthy (and it has the appearance of having been carefully drawn), it does not represent any species at present known, but it would be rash to deny that such a plant exists, until the Southern States have been better explored than they are at present. Delessert says of his plant "Crescit in Carolina (Fraser)," and it should be borne in mind that Fraser was acquainted with Walter, and is said to have attended to the publication of his "Flora Caroliniana" in London, so that he was in an excellent position to know Walter's species. DeCandolle says of *Nymphaea reniformis*, "(v. s.)," doubtless referring to one of Fraser's specimens, probably the same one from which Delessert's figure was drawn. So unless there is evidence to the contrary this figure must be accepted as representing Walter's *Nymphaea reniformis*, a species which should perhaps take rank with *Gordonia pubescens* and *Pyrola oxypetala* as being lost to science.

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* *Nymphaea reniformis* Walt. Fl. Car. 155. 1788; DC. Syst. 2: 55. 1821; Delessert, Ic. Select. 2: 3. *pl. 5.* 1823; DC. Prodr. 1: 115. 1824.

Nelumbium reniforme Willd. Sp. Pl. 2: 1260. 1799.

Cyamus reniformis Pursh, Fl. Am. Sept. 398. 1814; Ell. Bot. S. C. & Ga. 2: 68. 1821.

Nymphaea odorata β Torr. & Gray, Fl. N. Am. 1: 57. 1838.

N. odorata reniformis Lehm. Nymphaea, 13. 1853 (?)

In later years *N. reniformis* has been associated in synonymy with *N. tuberosa* Paine,* a northern species, but probably on insufficient grounds. About ten years ago Professors Trelease and Hitchcock independently transferred DeCandolle's *Nymphaea reniformis* to *Castalia*, apparently overlooking the fact that Walter was the author of the species. Professor Hitchcock's plant (from Iowa) is *C. tuberosa*, and the identity of that of Professor Trelease is immaterial, as he gave neither description nor synonymy. A few years later Mr. Nash † published the same combination, crediting the specific name correctly to Walter, but associating it with specimens collected by him in Lake Ella, Lake County, Florida, in 1894 (nos. 1153, 1180).

It is Mr. Nash's plant in which I am particularly interested, for I collected specimens which seem exactly to match his in Cane Water Pond, Decatur County, on the morning of August 13 last year (no. 1212). To avoid any possible confusion in the future,

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* *Nymphaea tuberosa* Paine, Cat. Pl. Oneida Co. N. Y. 132. 1865.

Castalia tuberosa Greene, Bull. Torrey Club, 15: 84. 1888; Britton & Brown, Ill. Fl. 2: 44. *f. 1532.* 1897.

Nymphaea reniformis "DC." A. Gray, Manual, ed. 6. 56. 1890; Syn. Fl. N. Am. 1: 76. 1895.

Castalia reniformis "(DC.)" Trel.; Branner & Coville, Rep. Geol. Surv. Ark. 1888⁴: 164. 1891 (name only); A. S. Hitchcock, Trans. Acad. Sci. St. Louis, 5: 484. 1892.

† Bull. Torrey Club, 22: 147. 1895.

I will designate my own specimens as the type of the foregoing description. Similar specimens are in the Columbia University Herbarium, collected in Louisiana by Dr. Hale, and in Thomas County, Georgia, by Dr. Small in 1895. But this southern plant seems to differ from *Castalia odorata* only in its larger size and more prominent veins on the lower surface of the leaves, and is probably entitled only to varietal rank at the most. It cannot be the *Nymphaea reniformis* of Walter,[*] so I have given it a new name as above.

The leaves of my specimens were fully as large as those described by Mr. Nash, and their edges were often slightly upturned, as also noted by him, allowing the wind to get under them and turn them partly over. This plant is very abundant in Cane Water Pond, and its leaves and flowers are the most conspicuous objects on the surface of the water there.

NYMPHAEA ORBICULATA Small, Bull. Torrey Club, **23**: 128. 1896

On August 9 I visited the type-locality of this species in Thomas County for the purpose of securing some authentic fresh specimens for Dr. Gerrit S. Miller, Jr., who is doing some work on the genus, and I had little difficulty in finding it (no. 1178). Four days later it was seen in Cane Water Pond, in the next county.

I can now correct an unfortunate error in the original description. Dr. Small says of the leaves, "the upper leaves rough with irregular papillae," but in reality the upper surface is perfectly smooth in life, but becomes rough in drying, as in some other species of the genus. Dr. Small calls the locality "a small lake," but it is nothing but a cypress pond, the level of which has been artificially raised a few feet for fishing purposes by a dam, and it could hardly be dignified by the name of lake.

SARRACENIA MINOR Walt.

S. lacunosa Bartr. Travels, 417. 1791.

S. variolaris Michx. Fl. Bor. Am. **1**: 310. 1803.

In a previous paper[†] I referred to the probable identity of

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[*] See in this connection Robinson, Syn. Fl. N. Am. 1 : 76. 1895.

[†] Bull. Torrey Club, 27 : 428. 1900.

Sarracenia minor Walt. with *Sarracenia variolaris* Michx. Walter's description, though of course very brief, is amply sufficient to distinguish this species from any other now known, but to settle the question finally I wrote in May, 1901, to Mr. E. G. Baker, of the British Museum, asking if the species was represented in Walter's herbarium, and if so what it was like. He very kindly complied with my request, and informed me that such a specimen existed, and that it was evidently the same as *S. variolaris* Michx., the only trouble being that it was not labeled *S. minor* but *S. lutea*, a name which was never published. But as the other species mentioned by Walter were also there, and correctly named, it was evident that the *S. lutea* of his herbarium must be the *S. minor* of his flora, the reason for the change of name probably being that there is another species with yellow flowers (*S. flava* L.), which is a much larger plant. *S. minor* and *S. variolaris* were rightly considered synonymous by Elliott and several other authors of that period, but for some reason their identity has been doubted by some later authors.

I have no additional notes on this species at the present writing, except that it seems to be the most widely distributed species of *Sarracenia* in the coastal plain of Georgia. It grows in company with *S. flava*, *S. rubra* and *S. psittacina*, as well as in many places where none of the other species are present. It is represented by my numbers 678, from Coffee County, September 21, 1900, and 854, from Bulloch County, June 10, 1901. I have also seen it in Chatham, Effingham, Emanuel, Tattnall, Sumter, Lee and Thomas Counties, always in moist pine-barrens. It is not known from Alabama, however, and I have not seen it within fifty miles of the Chattahoochee River in Georgia.

Sarracenia flava × minor

On June 10 I collected in moist pine-barrens in Bulloch County a single specimen of a curious plant which must be regarded as a hybrid between *Sarracenia flava* and *S. minor.* It consisted of a short horizontal rootstock, like that of most species of the genus, bearing a single erect leaf which seems in every way exactly intermediate between those of the two supposed parents. It was yellowish green, with the hood horizontal (ascending in *S. flava*, deflexed — though horizontal when pressed — in *S. minor*), pubescent and reticulated with reddish veins beneath. The dimensions of the pressed leaf are: length of tube, 34 cm.; diameter at throat, 5 cm.; length of hood, 6 cm.; wing, 5 mm. wide at the middle. This specimen (no. 855) is now in the U. S. National Herbarium.

Where I collected it both of the supposed parents (as well as *S. rubra*, which, however, could have had nothing to do with it) were growing in the immediate vicinity.

It is a curious fact that although there are numerous hybrid Sarracenias in cultivation,* with almost every possible combination of parentage, apparently none has yet been artificially produced between these two yellow-flowered species.

SARRACENIA CATESBAEI Ell. Bot. S. C. & Ga. **2**: 11. 1821

S. flava Catesbaei Mohr, Bull. Torrey Club, **24**: 23. 1897.

There seems to be considerable mystery still surrounding this plant, and the following notes may serve to throw some light on the subject. Elliott described the species from specimens collected by Dr. James Macbride in Chesterfield district (now county), in South Carolina (near the edge of the coastal plain), but states that these specimens are exactly similar to one of the figures on Plate 69 of the second volume of Catesby's "Natural History of Carolina." This, however, should perhaps not be taken too literally, for the figure referred to is a poor one and does not accurately represent any known species; but it most resembles the plant which is now usually accepted as *S. Catesbaei*. Croom, in his monograph of the genus,† states that he has seen Elliott's specimen and was unable to distinguish it from *S. flava*. Most subsequent authors seem to have accepted this view until Dr. Mohr revived *Catesbaei* as a variety in 1897, assigning the name to specimens collected on Lookout Mountain, in DeKalb County, Alabama. In his Plant Life of Alabama it is restored to specific rank. ‡

Last summer, on July 8, I collected in a boggy place southeast of Americus some specimens (no. 1021), which seem to represent this species, intimately associated with *S. rubra* and *S. Drummondii.* It was immediately recognized as a plant which I had seen six years previously in a similar locality about a mile away, where it was associated with the same two species. At that time (1895) the possibility of finding a species not in the standard text-books had never occurred to me, and I referred it to one of the other species. In thinking over the matter a few years later I came to the conclusion that it must be a hybrid between the two species associated with it, but last summer I was convinced that this could not be the case, as the resemblance of *S. Catesbaei* to *S. rubra* is rather remote, and it has some characters not possessed by either of the other two. Elliott says of *S. Catesbaei* that it can be connected with no other species than *S. flava;* but I have noticed a very close and probably hitherto unsuspected relationship between *S. Catesbaei* and *S. Drummondii.* The leaves of these two are of almost exactly the same size and shape, differing principally in coloring, and I fancied that I could almost detect an intergradation between them, for many of the leaves of *S. Catesbaei* had the upper parts of the leaves faintly white-spotted, like those of *S. Drummondii* but in lesser degree. The inner surface of the hood was also pubescent with stiff reflexed hairs, as in *S. Drummondii.* But all had the iridescent purple spot in the throat, a character which is shared only with *S. flava.* If my plant was a hybrid, *S. flava* could hardly be one of its parents, for that species is not known to occur within 27 miles of this place (and in all my travels in Georgia I have never yet seen it west of the Flint River, though it is abundant east of there).

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* See Nicholson, Dict. Gard., and Bailey, Cycl. Am. Hort.

† Ann. Lyc. N. Y. **4**: 104. 1836.

‡ Contr. U. S. Nat. Herb. **6**: 531. 1901.

If the flowers of my plant could be obtained its affinities would be better known, but strangely enough, I have never been able to find the slightest traces of flower or fruit on it. The flowers of this species seem to be very rare. Catesby figures two flowers with yellow petals on the plate cited by Elliott, but these probably belong with the other leaf figured on the same plate, which is a leaf of *S. minor.* Elliott says the flowers of *S. Catesbaei* are unknown to him. In the herbarium of Columbia University there are several very doubtful specimens labeled *S. Catesbaei,* but these are either without flowers or the flowers are detached and may not have been collected with the leaves, and besides they are so old that their color is lost.

Dr. Mohr says of *S. Catesbaei:* "Flowers yellow," but the specimens in his herbarium have no flowers. One of them is like mine, except for being smaller (as might be expected from the elevation at which it grew, 2,000 feet), but the other one so labeled looks more like *S. flava,* and it is possible that both species occur together on Lookout Mountain. The only flowering specimen of *S. Catesbaei* I have seen was collected at the same place by Professor A. Ruth in July, 1898 (no. 253).

But even without flowers *S. Catesbaei* seems to be sufficiently distinct from the other six species (all of which I have often seen in the field), which are often found sterile also (especially the two large ones, *S. flava* and *S. Drummondii*), whether on account of immaturity or unfavorable conditions I do not know.

Further observations of this species in the field, especially in the vicinity of Elliott's type-locality, are much to be desired.

CRATAEGUS CONTRITA Beadle, Biltmore Bot. Stud. **1**: 61. 1902

Collected in the dry deciduous woods about half a mile north of Whigham, on the Lafayette clay at 275 feet altitude, August 10 (no. 1184). The underlying formation here is the Chattahoochee (Upper Oligocene), the same as at the type-locality of this species, which happens to be also the type-locality of the formation.

CRATAEGUS INSIDIOSA Beadle, Biltmore Bot. Stud. **1**: 94. 1902

Collected in dry red clay soil among the hills a few miles northwest of Americus, July 30 (no. 1143). This species and the preceding have been identified for me by Mr. Beadle.

PRUNUS CUTHBERTII Small, Bull. Torrey Club, **28**: 290. 1901

Collected on the steep rocky slopes of the Pine Mountains, at 800 feet altitude, in Upson and Meriwether Counties, August 28 and 29 (nos. 1261 and 1267). Recently reported from Warm Springs in the latter county by Mr. C. L. Boynton.* This species is very different in aspect from some of its relatives, and in winter would hardly be taken for a *Prunus* at all. It is a small straggling tree with short crooked branches and rough bark not unlike that of a *Diospyros.* It seems to be closely related to *P. Alabamensis* Mohr.

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* Biltmore Bot. Stud. **1**: 145. 1902.

This is probably the same species found by Dr. Mohr on the mountains of Clay and Talladega Counties, Alabama, and referred by him to *P. serotina neomontana* Sudw., for his description* (written of course before *P. Cuthbertii* was published) exactly fits my specimens from the corresponding portion of Georgia.

KRAMERIA SECUNDIFLORA DC. (*K. lanceolata* Torr.)

Collected on the sand-hills of Big Lott's Creek, Bulloch County, June 27 (no. 971), and seen the next day in similar situations in Emanuel County, near the rosemary sand-hills. This species has not to my knowledge been reported from Georgia before, or from any adjacent state except Florida. In Bulloch County it is known as "sand-spur," a name which in Southwest Georgia seems to be applied exclusively to *Cenchrus echinatus*. But I found to my surprise that no species of *Cenchrus* seems to be known in the upper part of Bulloch County, and the farmers there are to be considered fortunate in not having made the acquaintance of these pests.

BAPTISIA PERFOLIATA (L.) R. Br.

A common and conspicuous inhabitant of the dry pine-barrens of Bulloch and other counties in the eastern part of Georgia. Collected along the railroad at Butts, Emanuel County, June 6 (no. 802). It has rather a restricted range, being known only from South Carolina and Georgia and probably not occurring west of the Ocmulgee River. The westernmost point at which I have seen it is in Montgomery County.

This species has several peculiarities which have never been described, though they are doubtless well known to the few botanists who have collected it. Its most striking feature is that the perfoliate leaves on the almost horizontal widely spreading branches are all placed vertically, exposing both surfaces equally to the sun and giving the plant a most striking appearance. The phyllotaxy is even more peculiar, the leaves being arranged very nearly in a single row on each branch, with the midribs all pointing toward the zenith. Strictly speaking, they alternate in two rows, with an angular divergence of 15 or 20 degrees between them, instead of 180° as in most cases of two-ranked leaves. These peculiarities are shared by no other species of *Baptisia*, and it is not surprising that this one was made the type of a new genus by Rafinesque.

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* Contr. U. S. Nat. Herb. **6**: 62. 1901.

MEIBOMIA PAUCIFLORA (Nutt.) Kuntze

Collected in rich shady woods near Chokee Creek, Sumter County, on the morning of July 25 (no. 1114). This species differs considerably from its relatives in its flowers. The corollas are not only pure white, as is hinted in the Illustrated Flora and Dr. Britton's Manual, but also more regular than in the other species. The two lower petals instead of being united into a keel are widely diverging, as are the very similar wing-petals. The corolla is therefore hardly papilionaceous, and almost the only evidence of irregularity about it is the larger size of the standard, which is three or four times as broad as the other petals. Most descriptions say nothing about the color of the petals of this species, but Mr. T. H. Kearney and Professor A. Ruth, who have collected it in Tennessee, inform me that their experience has been the same as mine in this respect.

This may perhaps be considered the most primitive species in the genus. In its other characters besides those mentioned it resembles very much its near relative *M. grandiflora* (Walt.) Kuntze, which was found intimately associated with it and collected at the same time (no. 1115).

EUPHORBIA ERIOGONOIDES Small, Bull. Torrey Club, **25**: 614. 1898

In rather dry pine-barrens, Bulloch County, June 10 (no. 846); not common. Previously known only from McIntosh County, where Dr. Small discovered it in 1895. My specimens are less branched than his, but otherwise identical.

HELIANTHEMUM ROSMARINIFOLIUM Pursh

This long neglected (and perhaps not yet very well known) plant seems to be the most abundant species in the vicinity of Millen, growing in dry sandy soil, where I collected it on June 5, (no. 759), at which time it was not yet in flower. Mr. A. H. Curtiss collected it five weeks later at Oliver, 33 miles farther down the Ogeechee River and Central R. R., (no. 6838, distributed as

H. capitatum Nutt.), and on his labels remarks: "In eastern Georgia covering hundreds of acres of old fields as densely as a sowed crop." This is equally true around Millen. It is also more or less abundant along roadsides in the upper part of Bulloch County, where I collected it in flower on the morning of July 1 (no. 986). The original specimens, collected by Enslen, probably came from somewhere in this part of the state. *H. rosmarinifolium* never has the appearance of a native, but seems to be a strictly ruderal plant, and I have never seen it a member of a perfectly natural plant-community. It probably belongs to the considerable class of native weeds, like *Phytolacca decandra*, *Ambrosia artemisiæfolia* and *Eupatorium ccmpositifolium.*

OSMANTHUS AMERICANA (L.) B. & H.

This species has hitherto been supposed to be confined to the immediate vicinity of the coast. But on July 19 I found it in some abundance in dry woods south of Omaha, which is 125 miles inland and probably about 300 feet above sea-level. Only a few of the specimens had fruit on them, however. It also grows on the rosemary sandhills in Emanuel County, on the sandy banks of the Flint River in Sumter County and of Muckalee and Kinchafoonee Creeks in Lee, and in Decatur County near Whigham, as well as on Tybee Island on the coast. It is usually sterile and therefore likely to be overlooked.

SABBATIA FOLIOSA Fernald, Bot. Gaz. **33**: 155. 21 F 1902

Collected in the swamp of Big Lott's Creek, Bulloch County, June 27 (no. 964), and on the shore of a small pond in Decatur County, August 12 (no. 1196). Both numbers have been examined and identified by Mr. Fernald. Seen also at several other points in Bulloch, Emanuel, Tattnall, Montgomery, Telfair, Dodge, Wilcox, Dooly, Thomas and Decatur counties. Mr. Fernald cites specimens of this species only from South Carolina and Florida. It seems to occur also in Alabama, for Dr. Mohr's specimens from Vinegar Bend, Washington County, mentioned in his Plant Life of Alabama as *S. dodecandra*, are good *S. foliosa*. Much of the southern material which has passed as *S. dodecandra* will probably turn out to be the latter species. Mr. Fernald informs me that there are no authentic specimens of the former in the Gray Herbarium from farther south than North Carolina.

The two species are very closely related, differing perhaps in habitat as much as in any other way. *S. dodecandra* seems to be mostly a maritime plant, while the usual home of *S. foliosa* is in creek and river swamps. *S. foliosa* seems to represent one extreme of the *dodecandra* group, of which *S. decandra* is the other.

ASCLEPIAS HUMISTRATA Walt. (*A. amplexicaulis* Michx., not J. E. Smith)

Grows sparingly in dry pine-barrens and on sand-hills in Bulloch County (no. 833, June 10), also seen in Effingham and Stewart counties, always on the Columbia formation. This is another species which seems never to have been completely described. Its glaucous fleshy leaves are so twisted at their points of insertion on the decumbent branches that they lie in vertical planes, giving the plant a very different appearance from any of its Eastern relatives, if not from all other species of the genus. The leaves are practically alike on both surfaces, and their vertical position is of course an example of a well-known adaptation for protection against excessive transpiration. The phyllotaxy of this species is also peculiar, the successive pairs of leaves being not decussate but parallel, analogous to the case of *Baptisia perfoliata* already mentioned.

Asclepias rubra laurifolia (Michx.)

A. laurifolia Michx. Fl. Bor. Am. **1**: 117. 1803.

Differs from *A. rubra* L., in the shape of the leaves, which are lanceolate from a cordate or somewhat hastate subsessile base, tapering uniformly to the apex, or the upper ones narrowed at the base.

Collected in low grounds near Muckalee Creek, Americus, July 29 (no. 1128). Accompanied by *A. lanceolata* Walt. (no. 1127), which it much resembles. Also found in former years in several similar localities within a few miles of Americus, but apparently quite rare, as I have never seen more than two or three individuals at one time.

Asclepias laurifolia Michx. has usually been regarded as identical with *A. rubra* L., but my specimens and others which I have seen (mostly from Georgia), agree very well with Michaux's description and are easily distinguished from *A. rubra*, a plant of more northern range, by the shape of the leaves, which appears to be quite constant. But as this is about the only difference, it seems best to treat Michaux's plant as a variety of *A. rubra*. This may possibly have been done before, but it would be impossible to ascertain this without wading through a great mass of literature. Michaux himself did not contrast the two plants, as he did not mention *A. rubra*. Miss Vail, who has seen his type specimen, which was found "secus amnem Althamaha, in Georgia," says that my specimens resemble it very closely. In the Columbia University Herbarium are specimens of the same plant collected in Georgia by Dr. Boykin and Dr. Chapman (without definite locality), and in Louisiana by Dr. Hale.

NAMA OVATA (Nutt.) Britton. (*Hydrolea ovata* Nutt.)

Collected in shallow water in the Slough near Camilla, Mitchell County, August 8 (no. 1170). I know of no other definite station in Georgia for this species, which is more frequent farther west. It is remarkable for being one of the few aquatic or semi-aquatic plants which are both pubescent and spiny. The spines are sufficiently numerous to make collecting disagreeable when one has to wade in after it barefooted.

COLLINSONIA TUBEROSA Michx.

In rich shady woods on the north side of a bluff of Oostanaula shale east of Dalton, Whitfield County, at 720 feet altitude, September 7 (no. 1287). Has very much the babit of *Phryma Leptostachya*, which grows with it, and its flowers have almost exactly the same odor as those of *Dicerandra odoratissima*. This *Collinsonia* seems to be quite rare, but it is imperfectly understood and its nomenclature is somewhat uncertain.

LINARIA FLORIDANA Chapm.

Collected on the rosemary sand-hills of Emanuel County, June 28 (no. 976); evidently long past flowering, and with over-ripe capsules. Previously known only from drifting sands along the Gulf coast.

PLANTAGO SPARSIFLORA Michx.

Seen only in rather dry pine-barrens about two miles south of Smithville, Lee County, where I collected it on the morning of August 3 (no. 1163). This species has much the appearance of some Melanthaceous plant, for which I mistook it at first glance. It seems to be very rare. There are no specimens of it in the U. S. National Herbarium or that of the New York Botanical Garden besides my own, but in the former there are two specimens so labeled, one from Illinois and the other from Kansas, which are something entirely different. The label of one of them bears a note to a effect that the capsules are 5-seeded, and the other one is similarly noted to have 6-seeded capsules; while in *P. sparsiflora* they are 2-seeded.

In the Columbia University Herbarium are two old and imperfect but unmistakable specimens of *P. sparsiflora*, one from North Carolina and one from South Carolina, as well as a very doubtful specimen from Louisiana and one from Illinois similar to those in the National Herbarium. All these western specimens are annual, while *P. sparsiflora* is perennial from a stout rootstook. Just what the western plant represents is not clear. It may be a form of *P. Virginica*, or perhaps Michaux's *P. Kentuckensis*, a species which seems never to have been recognized. *P. sparsiflora* is credited to Illinois in Britton and Brown's Illustrated Flora, doubtless on the basis of the specimens just mentioned, but it would be indeed remarkable if a species should occur both in Georgia and Illinois without being known from intermediate stations. The true *P. sparsiflora* is known only from the coastal plain of Georgia and the Carolinas, which is about the range given by the Michaux. My specimens, which were probably the first collected for many years, agree perfectly with the original description and most of the later ones.

VIBURNUM NITIDUM Ait. Hort. Kew. **1**: 371. 1789

V. nudum β angustifolium Torr. & Gray, Fl. N. Am. **2**: 14. 1841.

Collected in the swamp of a small pine-barren stream, Bulloch County, June 8 (no. 831), in fruit. This species does not seem to have been recognized by most recent authors, but my attention was called to it by a description in Dr. Mohr's Plant Life of Alabama,* which agrees very well with my specimens. It is very close to *V. nudum*, but can be distinguished in the field without much difficulty. *V. nudum* was collected near the same place two days later (no. 842).

VERNONIA MAXIMA Small, Bull. Torrey Club, **27**: 280. 1900

Abundant on the muddy banks of Mill Creek about two miles east of Dalton, Whitfield County, where I collected it on September 7 (no. 1292). Not previously reported from Georgia.

CACALIA SULCATA Fernald, Bot. Gaz. **33**: 157. 21 F 1902

I have known this species since August 22, 1896, when I first collected it in a sandy bog southeast of Americus, twelve miles from the type-locality given by Mr. Fernald. I have specimens collected at the same place August 20, 1897, and on the same date in 1900 (no. 435). This locality is especially characterized by the presence of *Juncus trigonocarpus* and *Sarracenia Drummondii.* I was never able to refer my specimens to any described species until I saw Mr. Fernald's description, which I immediately recognized as belonging to my plant. I have not seen any of the type material (Curtiss's no. 6884A, from Smithville, Lee County, Ga., August 26, 1901), the only specimen of it distributed by Mr. Curtiss being in the Gray Herbarium, but Mr. Fernald has compared one of my specimens with the type and pronounces them identical.†

This species of course belongs to the genus *Mesadenia* Raf., but Mr. Fernald does not consider *Mesadenia* distinct from *Cacalia*, and as I have not sufficient knowledge of these plants to disagree with him, I refrain from changing the name.

COLLEGE POINT, N. Y.

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*Contr. U. S. Nat. Herb. **6**: 744. 1901.

† I have recently (October, 1902) seen a specimen of the same thing collected in Lee Co., Aug. 20, 1894, by the late Mrs. Sarah Thompson, of Smithville.

The Publications of the Department of Botany, C lumbia University, consist of Memoirs in quarto a Contributions in octavo.

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CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 204

THE DEPARTMENT OF BOTANY AND ITS RELATION TO THE NEW YORK BOTANICAL GARDEN

By LUCIEN MARCUS UNDERWOOD

NEW YORK
1903

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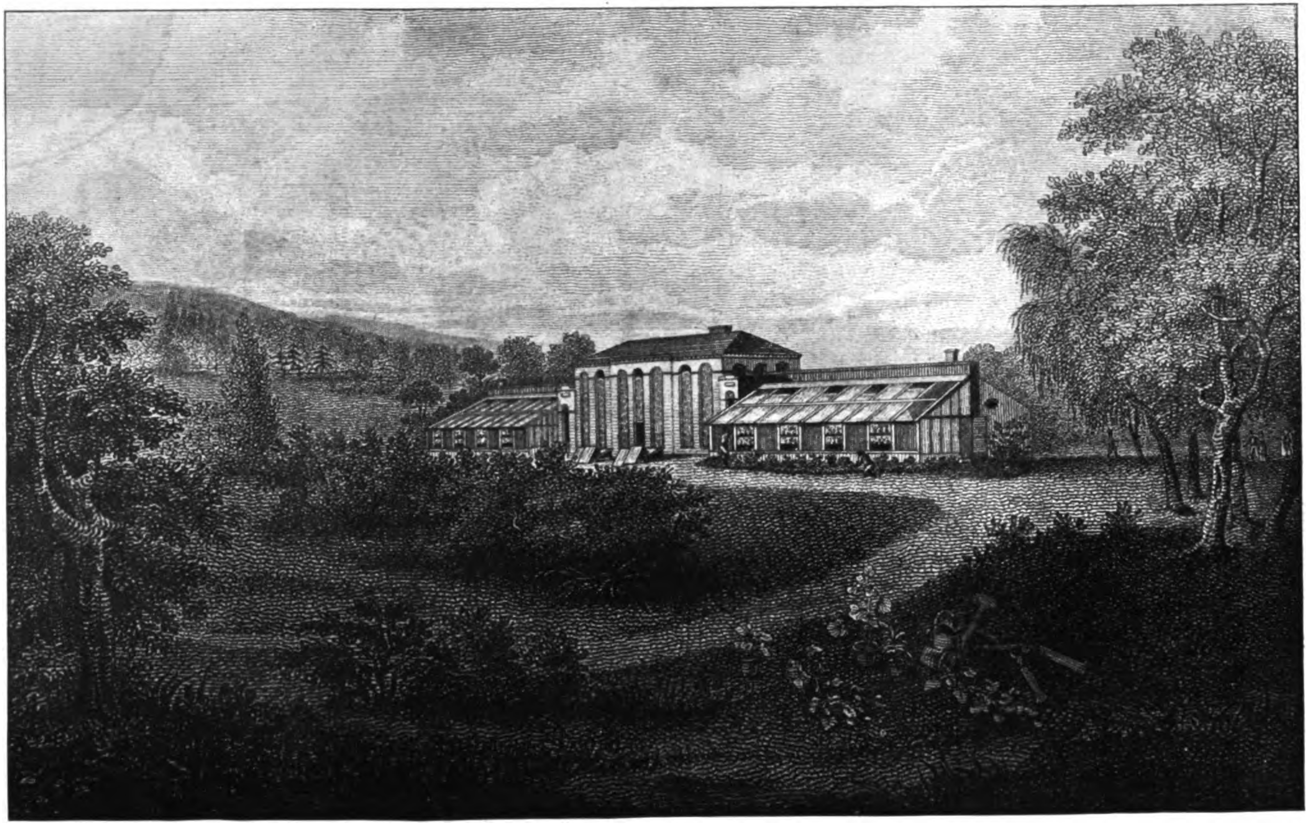

HOSACK BOTANICAL GARDEN, 1801
FIFTH AVENUE AND FIFTY-FIRST STREET

THE DEPARTMENT OF BOTANY

And its Relation to the New York Botanical Garden

THE subject of botanical gardens will ever possess unusual interest to the friends of Columbia University because of the peculiar relation which the financial standing of the University bears to the first botanical garden of New York a century ago. Samuel L. Mitchell, the founder and long the first president of the old Lyceum of Natural History (now the New York Academy of Science); David Hosack, the founder of the Elgin Botanical Garden; John Torrey, the Nestor of American botany; and Nathaniel Lord Britton—these are four of the five names that appear on the roll of the University in the Department of Botany prior to 1896,* and each of the last three deserves special notice in connection with the development of the present condition of botany in New York. Hosack and Torrey were more closely connected with the College of Physicians and Surgeons, where instruction in botany was formerly a part of the medical course, and Britton was really the first to give instruction in Columbia College proper. At this time, however, it is unnecessary to consider these details, and the development of the science of botany in New York may be treated as a unit in which Columbia has ever been a leading factor.

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* The complete roll with date of service is as follows: Richard S. Kissam (1792–1793); Samuel L. Mitchell (1793–1795); David Hosack (1795–1811); John Torrey (1860–1873); Nathaniel Lord Britton, adjunct professor (1890–91), professor (1891–1896), emeritus professor (1896); Lucien Marcus Underwood (1896———).

The Elgin Botanical Garden* was located between Fifth and Sixth avenues just below Fifty-First Street; but during its brief existence in the first decade of the last century it was too far out of town to be much visited by the residents of the small city at the lower end of Manhattan Island. It was soon given to Columbia College to manage as a botanical garden; and finally, in exchange for certain land-claims which the College held against the State, it was made over to the Trustees of the College to use as they pleased. It has ever since remained a part of the University property; and the income from its rentals forms no inconsiderable portion of the available assets of the University. A most interesting memorial of the Elgin Gardens is still to be seen in the two noble yews that flank the steps leading to the University library. These stood originally in the Elgin Gardens and were early transplanted in what is now South Field, whence they were removed to their present position during the winter of 1894–95.

It will perhaps not be amiss to diverge a moment to another work performed by David Hosack, inasmuch as it bears directly upon the development of botany and botanical instruction in America at large. A young law student, Amos Eaton by name, came under Hosack's influence and was a frequent visitor at the Elgin Gardens. Soon afterwards he became a teacher of the science. His class in botany at Williams College, which contained every student at the college but two, unanimously requested the privilege of publishing the manuscripts of his work in botany. This formed the first of a series* of botanical manuals which passed through eight editions and were the forerunners of a later series which Asa Gray carried through five additional editions during his lifetime. Eaton was afterwards connected with the school of engineering at Troy. While detained in a debtor's prison in New York City for the supposed mismanagement of an estate in Columbia County, he amused himself, as he related long afterwards, by giving instruction in botany to the son of his jailor. The bright boy who thus drank in his first inspiration in botany from Eaton, and who was afterwards a student under Dr. Hosack, was none other than John Torrey.†

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* A large painting of the Elgin Garden which has long been in the possession of the Hosack family has recently been presented to the New York Botanical Garden.

When the annals of American botany are finally written, no name will have a more conspicuous position than that of John Torrey. An enthusiast in botany almost from boyhood; a life-long devotee of the science; a master in the art of botanical description and illustration; a world-renowned writer of botanical memoirs; a man of simplicity of life and manner, of becoming modesty regarding his own merit, of unblemished integrity and worth,—John Torrey, both as a man and a botanist, holds first place in our science. In what degree Torrey had made New York a botanical center as early as 1831, is seen in the fact that Asa Gray, restive in his work in central New York and casting about for a place where he could study botany, could find no better tutelage than under

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* A copy of this first edition, now one of the rarest works on American botany, was recently obtained by the librarian of the New York Botanical Garden in an old book shop in the city. With characteristic modesty Eaton refrained from placing his name on the title page.

† Amos Eaton was the grandfather of the late Daniel C. Eaton, who was a pupil of Asa Gray and afterwards became the first professor of botany at Yale. His library and collections form the foundation of the present department of botany in that University.

Torrey, and came to New York as Torrey's pupil. Later Torrey associated Gray with himself in the preparation of the "Flora of North America," a work that will ever stand as a classic in American botany, combining with the critical acumen and exact learning of its senior author the enthusiasm and push of its more youthful one. Gray remained at New York until, in 1843, he received his call to Harvard University, where he established a second center of botanical research. The annexation of Texas, as the second of our acquisitions of Spanish territory; the Mexican war and the commencement of our expansion policy in the acquisition of California and New Mexico, with the attendant military occupation and exploration for the settlement of boundaries; the discovery of gold in California in 1848 and the resultant development of that Eldorado of immigration; and finally the transcontinental railroad projects of the early fifties,—all these movements brought to Torrey and Gray the floral wealth of new territories, and made the Torrey herbarium at New York and the Gray herbarium at Cambridge two great repositories of the early types of western plants, each supplementing the other in their priceless possessions.

At Torrey's death, in 1873, his entire collection and his botanical library came into the possession of Columbia College. It was for many years located in a house on Madison Avenue, whence it was first removed to a precarious position in the "maison de punk," and thence to the crowded quarters in the uppermost stackroom of the library building on Forty-Ninth Street. The botanical museum not being ready at the time of the sale of the old site, the collection was temporarily placed in 502 Schermerhorn Hall until it was finally deposited with the New York Botanical Garden in 1898.

About the time the College came into the possession of the Torrey herbarium, two other large collections were acquired through the generosity of John J. Crooke, Esq., *viz.*, the Chapman herbarium, on which Dr. A. W. Chapman of Apalachicola, Florida, had based his "Flora of the Southern States," and the Meisner herbarium, which had been accumulated by Professor C. F. Meisner of Basel, one of the prominent contributors to De Candolle's "Prodromus." The shifting of the sheets of these three great collections into a single series formed one of the first pieces of botanical work of a young man who afterwards became professor of botany in Columbia and, at his retirement in 1896, the youngest emeritus professor of any American University. This piece of work, which to an ordinary student would have been merely mechanical, became to the alert mind of Dr. Britton a most valuable botanical education; and the impressions of relationships of the parts of the botanical system which he then gained have never been forgotten. A sheet once seen was so impressed on his memory that it was always remembered; and to this day it is the marvel of all his associates that he can so readily locate a given plant preserved in this enormous collection. So long as the College remained at Forty-Ninth Street, the congested conditions precluded the development of any except rudimentary laboratories; and Dr. Britton most wisely employed his energies and his departmental appropriations in the enlargement of the collections and the completion of the botanical library. In this way collections and books that are no longer obtainable were added to our stores; and when the transfer of the library and herbarium was finally made to the Garden, they contained over 5,000 bound volumes, besides quantities of unbound pamphlets, and nearly a half million specimens.

It was during Dr. Britton's professorship that Barnard College was organized, and the Department of Botany was the first to be established in that college under the efficient leadership of Dr. Emily L. Gregory, who held the position until her death in 1897. Dr. Britton for a time was acting dean of Barnard. He was also active in the organization of the graduate School of Pure Science, and was secretary of its faculty until his resignation in 1896.

Dr. Britton's efforts had long been exerted in promoting botanical work, not in Columbia College only, but in a wider field. Through the Torrey Botanical Club*—an organization that had grown out of occasional meetings of local amateur botanists about Dr. Torrey during his later years—Dr. Britton and others commenced a systematic movement toward the formation of a botanical garden in New York. Into this work Dr. Britton entered with characteristic energy and quiet enthusiasm, and the present development of the New York Botanical Garden stands as a living monument of his service to botany in America. The patient endurance of adverse criticism during the Garden's formative period; the adroit management of all the intricate and often delicate problems that have arisen in its development; the broad-minded views involved in the plans for its scientific equipment; the consummate skill with which a most harmonious body of workers has been brought together, and the prodigious amount of scientific work accomplished in the midst of trying administrative details—these are best known to the men who have been associated with Dr. Britton in his far-sighted undertaking.

The New York Botanical Garden is a corporation established by an act of the State Legislature, first passed in 1891 and amended in 1894. Its Board of Managers is composed of (1) *ex-officio* members, *viz.*, the mayor of the City of New York and the president of the Department of Public Parks; (2) elected managers, to the number of twelve; and (3) scientific directors. The last body, which, according to the act of incorporation, has "the management and control of the

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*The Torrey Club commenced the publication of a monthly four-page *Bulletin* in 1870. Its twenty-ninth volume, containing vi + 725 pages and 26 plates, has just been completed. Besides this, it began in 1889 the publications of *Memoirs*, which have now reached the twelfth volume, and more recently a smaller monthly, *Torreya*, now commencing its third volume. During the year 1902 the total scientific publications of the Club aggregated 1761 octavo pages and 90 plates, which exceeds that of any other scientific organization in America.

scientific and educational departments" of the corporation, is composed of the president and the professors of botany, geology and chemistry in Columbia University, the president of the Torrey Botanical Club, the president of the Board of Education of the City of New York, and such other persons as may be elected by the Board of Directors and approved by the entire Board of Managers. At the present time only one person, Dr. H. H. Rusby, has been thus elected, so that of the seven members of this board, four are representatives of the University.

The act of incorporation also authorized the setting aside of two hundred and fifty acres of park land, and the erection by the City of a fire-proof museum building and conservatories for the culture of tender plants at an expense not to exceed $500,000, conditional on the raising of an endowment fund of not less than $250,000 by the Board of Managers.

Subscriptions were soon opened for this endowment, Columbia University standing at the head of the list with a subscription of $25,000, and in June, 1895, the fund reached the statutory amount of $250,000. Dr. Britton, who had been connected with the development of the Garden from the outset, and who had personally gone over the available park land and had selected the north end of Bronx Park as the most desirable site for a garden, was chosen director in 1896; and the writer was elected to the professorship in Columbia thus vacated. After various delays the explanation of which may be left to the future historian, the plans were accepted, the building fund was appropriated by the City, and ground was broken for the museum building in December, 1897. The museum, completed except for the two wings left for future expansion, was handed over to the director in 1899. Ground for the large conservatory was broken in January, 1898, and the first plants were installed in about three-fifths of the completed structure in June, 1900; the remaining portions were completed, by the aid of a subsequent appropriation, in May,

1902. Grading and planting the grounds have proceeded as rapidly as possible and, with the working out of the present contracts, the ground plans will be fairly established on permanent lines.

The scheme of the Garden is primarily educational; and, as an educational institution it is maintained by the City, like the Museum of Natural History and the Metropolitan Museum of Art. The educational features of the Garden can be summed up under the following heads:

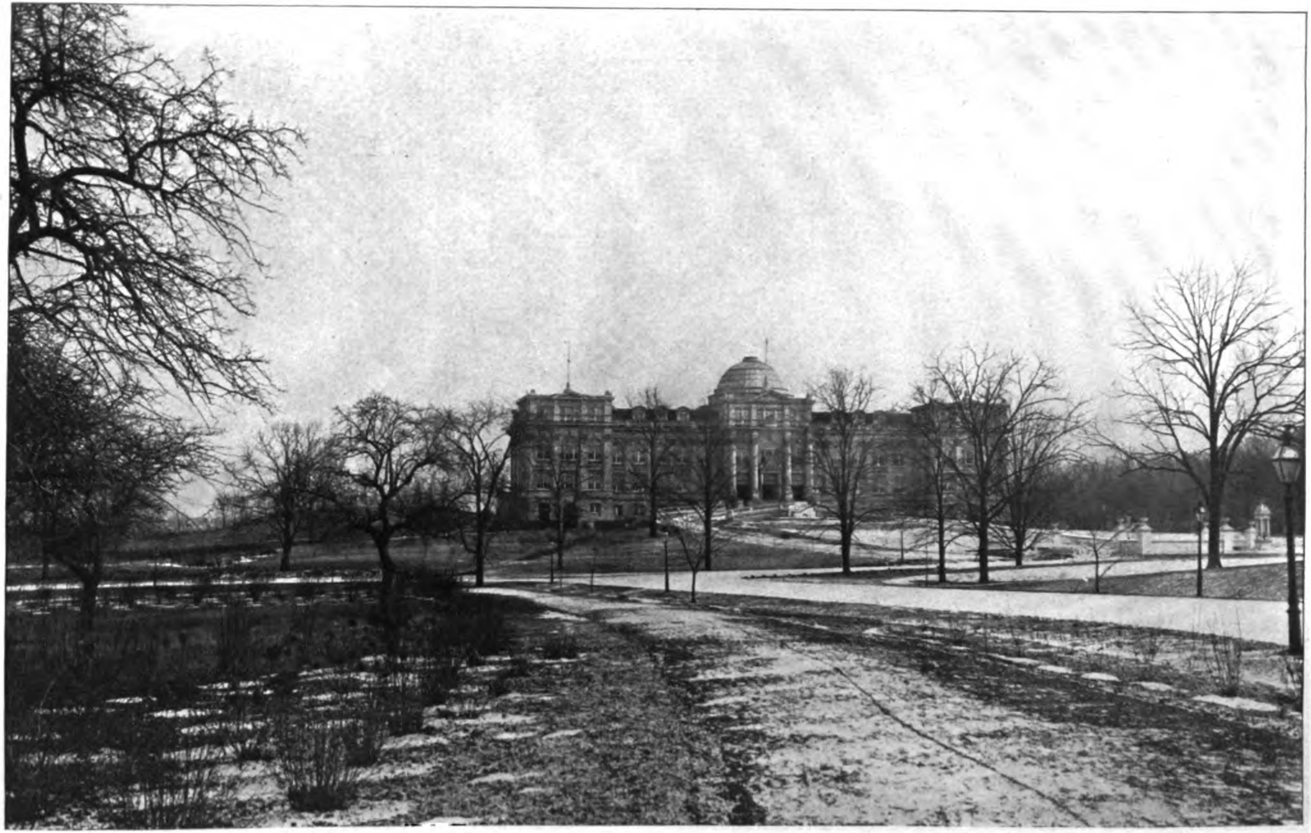
A. *For the education of the general public.*

I. PLANTATIONS.

1. Herbaceous grounds, containing such plants as will grow in the open, arranged according to natural relationships.
2. A fruticetum, containing hardy shrubs or low woody plants similarly arranged.
3. An arboretum, with named examples of hardy trees arranged in family groups as far as possible. (In some instances it will take years to furnish mature examples, but there are already in the park many fine trees of numerous species.)
4. Conservatories, for plants too tender to endure the climate at our latitude. These are arranged, as far as needs of cultivation permit, in family groups.

II. MUSEUMS.

1. A floor of the museum building devoted to exhibits showing the relation of plants to man or, in other words, economic plants, their products and methods of preparation.
2. A floor devoted to exhibits showing the relations of plants to each other, consisting of illustrations by various means of the structural characters of the various types of plants. A feature of this series is the exhibition in swinging frames of specimens of all native plants of the local flora, *i. e.*, those growing within 100 miles of New York City.



BOTANICAL MUSEUM, BRONX PARK, 1903

3. A palæo-botanical exhibit showing the types of fossil plants. The rich accumulations made under Professor Newberry and Dr. Hollick, and deposited by Columbia University, form the basis of this collection.

III. LECTURES. A course of popular illustrated lectures, given at present each Saturday afternoon during spring and autumn.

B. *For the education of botanists.*

I. LABORATORIES. These occupy the entire upper floor of the museum building and are fitted up for research instruction in every phase of botanical work—physiological, pathological, economic, taxonomic. These are supplemented by special rooms in the nursery greenhouses for experimental work—rooms which can be set aside for students' use as required.

II. LIBRARY. The botanical library now numbers over 12,000 volumes, having more than doubled since the removal of the Columbia nucleus to the Garden. Botanical periodical literature is especially well represented.

III. HERBARIUM. The combined collections of Columbia and the Garden now amount to over a million specimens. Additions are made at a rate of over fifty thousand specimens a year. During two exceptional years, over two hundred thousand specimens were added.

During the calendar year 1902 forty-four research students were registered at the Garden for longer or shorter periods. This list includes the graduate students of the Department of Botany at Columbia and others who are primarily registered at the Garden. In all, graduates of thirty-one colleges were represented among these research students.

At the last meeting of the Board of Managers two scholarships for advanced workers were established, of sufficient value to cover necessary living expenses. They are intended for persons who are prepared to carry on for a definite period (two to six months) some line of research and who can profitably use the extensive facilities offered at the Garden. This is practically a new type of scholarship: it is not intended for the ordinary graduate student, but for such as have already passed the period of their novitiate.

The scientific work of the Garden is conducted on various lines and is proceeding as rapidly as financial encouragement will permit. The following are some of the undertakings completed or in progress:

1. Exploration of regions little known botanically. During the past three years exploring parties, larger or smaller, have visited the following regions: Bermuda, Newfoundland, Nova Scotia, Arizona, Texas, California, Colorado (2), Montana, St. Kitts, Puerto Rico (2), Jamaica, Florida (2), Mexico, Sumatra, and Bolivia. Exploring parties are at present in Mexico, Honduras, Jamaica, and Cuba.

2. The preparation of floras of definite regions. While not an official publication accredited to the Garden, Dr. Britton's "Flora of North-Eastern America" may be mentioned as a part of the work of the staff. Dr. J. K. Small also is printing a "Flora of the South-Eastern United States," which will soon be issued, and Dr. P. A. Rydberg has in preparation a similar "Flora of the Rocky Mountain Region."

3. The North American Flora. This work had its inception in a correspondence between Dr. Britton and the present writer early in 1893. Plans were soon after formulated for the publication of a complete flora of North America, north of Mexico, in sixteen volumes to be issued in parts. Two barriers however existed which delayed the early progress of the work: both Dr. Britton and the writer were fully employed in other work connected with perfecting the plans of the Botanical Garden, and the enterprise lacked the financial support necessary or at least desirable to ensure entire success. Meanwhile the Spanish War of 1898 changed the political map of North America and plunged us unawares into the midst of tropical

botany. This necessitated a revision of the entire plan of the work, and the completion of many of the vexing preliminary plans for the Garden left us more free to take up again this earlier project. Under the will of Judge Daly we received a large bequest which could be applied to publication, and we are now in a position to proceed with the work. The new plan involves an extensive addition to the previous geographical scope of the work, so that it now includes the West Indies, Mexico and Central America, in all of which regions botanical exploration is being rapidly carried on. This involves an increase in the number of proposed volumes from sixteen to thirty-one. The first two parts which are now nearly ready for the press, will be issued during the present year.

4. Serial Publications. Four series are maintained at the Garden:
   - (a) *Journal.* Published monthly, primarily for the benefit of members of the Garden; giving reports of accessions and memoranda relative to the progress of work.
   - (b) *Bulletin.* Published at intervals; giving official reports of progress, and often shorter scientific papers by various members of the staff.
   - (c) *Contributions.* Consisting of reprints of papers by officers or students of the Garden published elsewhere than in the above series.
   - (d) *Memoirs.* Containing more formal and extensive papers by members of the staff. Two volumes have already appeared and a third is in press.

By a grant from the Carnegie Institution of $8,000 for the first year, a laboratory at Tucson, Arizona, for the study of problems connected with desert vegetations and the economic problems resulting therefrom has been made possible. The entire management is vested in Mr. F. V. Coville, botanist of the Department of Agriculture at Washington, and Dr. D. T. MacDougal, director of the laboratories at the Garden. This new project opens up a line of physiological botany on an extensive scale and in an entirely new field of research, and thus becomes a prominent side interest for the Garden staff.

The undergraduate work of the Department of Botany of Columbia University is carried on in three somewhat independent sets of laboratories, which in time may be more closely coördinated. (1) The department at Barnard College, originally established as an independent professorship, has been placed, since the death of Dr. Gregory, under the management of Dr. H. M. Richards, with two assistants. (2) At Teachers College, the botanical work is under Professor Francis E. Lloyd, with one botanical assistant. Both Professor Lloyd and Dr. Richards have charge of graduate courses in addition to general or undergraduate work. (3) For the undergraduate work of Columbia College and the Schools of Applied Science, extensive laboratories are fitted up on the third floor of Schermerhorn Hall. A half-year's instruction is given to students in civil engineering and three years' undergraduate work is offered to students of Columbia College. Practically the whole development of the undergraduate laboratories has been accomplished since the removal to the new site in 1897. Laboratories for general morphology and physiology, growing-chambers, dark rooms, lecture room with lantern equipment, and a valuable series of charts and apparatus have been gradually accumulated from a special appropriation at the outset and the usual annual appropriation of the department. In a series of special cases the leading features of the plant system are exhibited in a synoptical way, and a series of preparations in jars illustrate the principal features of plant morphology and the life histories of typical plants; a series of swinging cases are in preparation to illustrate the trees and other woody plants of the North-Eastern States, showing leaves, flowers, fruit, bark and wood. An extensive series of photographic illustrations of various phases of plant communities and types of plant growth form an important educational and decorative adjunct of the halls, supplemented by a series of illustrations from foreign botanical gardens. For the preparation of these photographs, collections and illustrations the department is indebted to the self-sacrificing and painstaking efforts of Dr. Carlton C. Curtis, who has accomplished this accessory work in the midst of arduous labors in the class room, laboratory and field with the undergraduates of Columbia, and at the same time has been carrying on intricate researches in several problems of plant physiology. The department needs only a special endowment to make its efficiency complete. Besides Dr. Curtis, the department has at present a single assistant.

The publications of the Department of Botany consist of *Memoirs* and *Contributions,* besides miscellaneous publications not included in either series. Two volumes of *Memoirs* in quarto have been published, containing monographs by Dr. John K. Small and Dr. P. A. Rydberg, representing their dissertations for the doctorate. Succeeding volumes of this series will contain a monograph of the North American Ferns by the present writer. The *Contributions* were started in 1886 and have just reached a total of 200 numbers (eight volumes). These consist of reprints of botanical papers published in various periodicals by students of the department or members of the staff.

Miscellaneous publications, not included in the above lists, form some of the most extensive memoirs issued by members of the department. Among these may be noted specially the dissertations of Dr. M. A. Howe on "The Hepaticæ and Anthocerotes of California" (35 plates), of Dr. David Griffiths on "The North American Sordariaceæ" (19 plates), of Dr. Tracy E. Hazen on "The Ulothricaceæ and Chætophoraceæ of the United States" (23 plates), and an important paper by Professor Lloyd on "The Comparative Embryology of the Rubiaceæ" (15 plates). Among other contributions to botanical science emanating from members of the department and soon to be published, we may mention the important discovery of a cytological basis for the Mendelian law by Dr. W. A. Cannon, fellow in botany, 1900–1902, resulting from his study of hybrid cottons, and the economically important starch investigations of Dr. A. P. Anderson, assistant in botany, 1901–1902, which are destined to revolutionize our present imperfect system of the preparation of starchy foods.

The exact relations between the Department of Botany at Columbia and the New York Botanical Gardens can best be understood by a reading of the original contract between the institutions:

This agreement, made at the City of New York, this eighth day of January, one thousand eight hundred and ninety-six, between the THE NEW YORK BOTANICAL GARDEN, party of the first part, and THE TRUSTEES OF COLUMBIA COLLEGE in the City of New York, party of the second part.

Witnesseth, That THE TRUSTEES OF COLUMBIA COLLEGE have agreed and by these presents do agree to deposit the Herbarium and Botanical Library belonging to the College (except such minor part thereof as it shall deem necessary for undergraduate instruction at the College) with THE NEW YORK BOTANICAL GARDEN, at the request and for the use of said Garden, upon the considerations and for the purposes and subject to the conditions following:

1. That the officers and students of Columbia College may freely consult and use the same as heretofore, as well as the Library and Herbarium collected by the Garden, and that both the Library and Herbarium of the College shall be kept satisfactorily insured by the Garden.

2. That Columbia College, either alone or in coöperation with other institutions, may conduct university courses at the Garden for graduate or advanced students in botany and kindred subjects, which shall be free to their own students, and, as the authorities of the Garden may prescribe, to students at the Garden or from other institutions; that the reasonable use of the laboratories and floral material from the Garden needed for study shall also be available to such officers and students without charge, subject to any necessary regulations by the authorities of the Garden.

3. That all courses of instruction given at the Garden shall likewise be open to the officers and students of Columbia College without charge; and so far as reasonably practicable, botanical material needful for study shall be supplied to Columbia College

for undergraduate work, as well as to other colleges, the public schools and other public educational institutions, subject to the regulations of the Garden authorities.

4. That students studying at the Garden who are not matriculated students of Columbia College or of any other college, may be admitted without charge, on the request of the authorities of the Garden, to such courses at Columbia as said authorities may recommend and the College may approve.

5. That the Columbia Library and Herbarium and all accessions thereto made by the College or in its behalf, while on deposit at the Garden shall be kept distinguishable from the Library and Herbarium of the Garden, by such means as shall be approved by the College, so as to be easily separable in case of removal.

6. That Columbia College reserves the right to retain or to recall at any time so much of its Herbarium and Botanical Library as it may deem necessary for use in undergraduate instruction.

7. That either party may terminate this arrangement on one year's notice to the other.

The Department of Botany is thus placed in direct contact with the largest botanical institution in America, housed in the largest botanical building in the world. Library and herbarium facilities increasing with a rapidity which would have been impossible in a university department; laboratories specially equipped for research; the use of special culture rooms in conservatories; constant temperature rooms for conducting physiological experiments; a chemical laboratory fitted for complete plant analysis; and, best of all, direct contact with a large coterie of specialists each working along a different line of botanical research—these are only a few of the opportunities that can now be offered to graduate students in botany at Columbia University. As guides in their work they may select any of sixteen specialists, each representing different phases of the present multiplex study of plant life.

To one who, only twenty-eight years ago, found the college instruction in botany confined to a two-hour course, extending through a short term of ten weeks, the present tender of the department seems like the realization of an impossible dream.

LUCIEN MARCUS UNDERWOOD

The Publications of the Department of Botany, Columbia University, consist of Memoirs in quarto and Contributions in octavo.

The Memoirs already published are:—

Vol. I. **Small.** A Monograph of the North American Species of the Genus *Polygonum*. Pp. 178. 84 plates. 1895. Price, six dollars.

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The Contributions have now reached the ninth volume.

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Vol. II. Nos. 26–50 (1892–1894). Nos. 26, 28, 29, 32, 33, 34, 36, and 39 are out of print; other numbers can be supplied at twenty five cents each, except No. 35, which is one dollar and a half.

Vol. III. Nos. 51–75 (1894–1895). Nos. 52, 54, 60, and 72 are out of print; others can be supplied at twenty five cents each.

Vol. IV. Nos. 76–100 (1895–1896). Five dollars; single numbers twenty five cents each.

Vol. V. Nos. 101–125 (1896–1897). Five dollars; single numbers twenty five cents, except No. 119 which is fifty cents, and No. 101 which can only be supplied with full volumes.

Vol. VI. Nos. 126–150 (1897–1898). Five dollars. Nos. 133, 136, 146, and 150 can be had only in orders for the complete volume; other numbers, twenty five cents, except Nos. 129 and 143, which are fifty cents each.

Vol. VII. No. 151–175 (1898–1901). Five dollars. Nos. 157 and 158* cannot be furnished separately; other numbers twenty five cents each.

Vol. VIII. No. 176–200 (1901–1902). Five dollars; single numbers twenty five cents, except No. 176 which is fifty cents.

Vol. IX. No. 201—(current).

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* Nos. 157 and 158, with the set of nine papers by Mr. Bicknell on *Sisyrinchium*, can be had for one dollar and fifty cents.

Lists of titles of Contributions may be had on application.

LUCIEN M. UNDERWOOD,
Professor of Botany.

COLUMBIA UNIVERSITY,
NEW YORK CITY.

RECEIVED
23

CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 205

A NEW AND CHEAP FORM OF AUXANOMETER

BY F. E. LLOYD

NEW YORK
1903

[Reprinted from TORREYA, 3: 97-100. July, 1903]

pam.
LIBRARY OF THE GRAY HERBARIUM
HARVARD UNIVERSITY.
THE GIFT OF

A NEW AND CHEAP FORM OF AUXANOMETER

By F. E. Lloyd

It is very much more interesting and instructive, in elementary courses in botany, to observe periodicity of growth in plants than merely to demonstrate, by means of a lever, what every one knows already, namely, that plants grow. It is sounder pedagogically to do such experiments quantitatively, since, when so performed, they mean very much more in training. It is for this reason that attempts have been made to construct a cheap form of auxanometer by attaching a recording cylinder to the minute-hand spindle of an ordinary clock. It is obvious, however, that the centering of a cylinder, and its vertical adjustment without lateral movement, are by no means easy of accomplishment. A cylinder is very likely to revolve irregularly unless made with very great care, a process which involves turning and centering on a lathe, and skilful mechanical adjustment to the clock. I have to confess to failure in this direction, except after a too great expenditure of time and labor. Happily, however, this experience has led me to devise a very cheap and accurate mechanism which accomplishes the end desired, and this at a very small cost of money, time or skill. This is done by substituting for a revolving cylinder, a lever, which is jogged once an hour by an arm moved by the minute-spindle of a seventy-five cent clock.

As will be seen by the illustration, the lever bearing the record is fixed on a horizontal axis, and stands vertically upwards, held against a block by means of a thread, reeved through a wire pulley, drawn sufficiently taut by means of an attached weight. This weight must be heavy enough to draw back the record lever to the block when it has been displaced from the vertical, say from 0.5 to 1.5 cm., according to the length of the lever and of the record. The arrangement of thread and weight was chosen because, with a little adjustment, the lever may thereby be pulled back quietly and quickly without shock or vibration, after it has been moved by the minute-spindle arm. To set up such an apparatus one may proceed as follows: Take a box, a wooden packing- or mailing-box of suitable size, say approximately a cube, 15–20 cm. on a side, fill it with gravel and nail it up. This makes a good, solid stand. Its solidity is enhanced by gluing on the under side as feet, three bits of thin cork. Upon

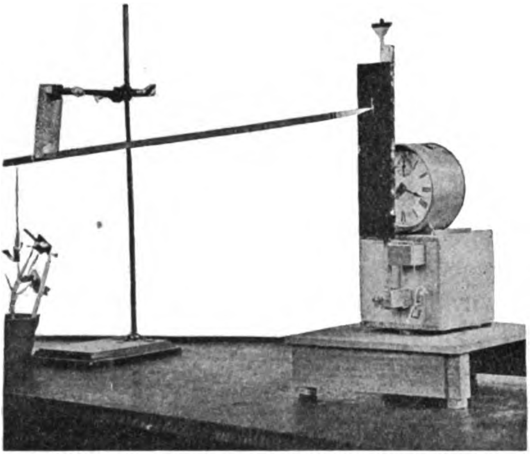

Fig. 1.

the top of this stand is affixed a cheap clock from which the glass face has been removed. Its minute-hand must be suitably bent in an L, or in its place an L-shaped arm affixed to the spindle, so that during its rotation, it will move against a shoulder or pin on the record lever. This lever is a wooden arm on an axis attached to the side of the stand below the clock. A little care must be given to adjusting the axis — a wire nail serves very well — so as to avoid any lateral shake. The shoulder or pin upon which the minute-spindle arm plays should be arranged so that the record lever will be moved but a little distance, and then be released. It will then be drawn quickly back to its vertical resting position against the wooden block. It is plain that the recording point of the auxanometric lever itself, which is attached to a growing plant, will make a horizontal mark, if allowed to drag across a sheet fixed to the lever arm, or exactly speaking, an arc of a large circle. Since the end of the lever, attached to the plant is constantly falling as the plant grows, it is obvious that the distance between these marks, which will be made at hourly intervals, will show a record of the growth, amplified of course, in the ratio of the lever arms. The chief difficulty, and this is but a slight one, is in getting the planes of the two levers sufficiently parallel, so that the recording point will work freely and at the same time not swing away from the surface on which the record is to be made. When this trifling obstacle has been overcome, one has a piece of apparatus which will give a beautifully exact and clear record of hour intervals of growth. It will readily be seen that half-hour intervals may be obtained by having a double arm or by placing two

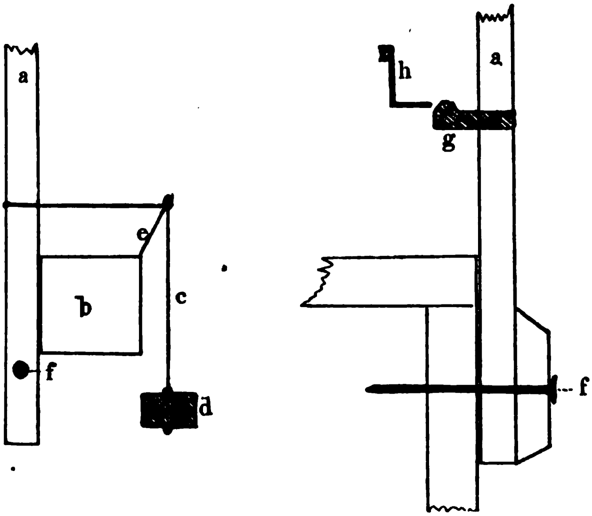

FIG. 2. Sketch to show details of lever-mechanism. *a*, lever, carrying record; *b*, wooden block; *c*, thread, to which is attached weight, *d*, and which moves through bent wire pulley, *e*; *f*, pivot; *g*, shoulder on which the arm attached to minute-hand spindle, *h*, impinges; if the latter is bent once more at right angles, the shoulder, *g*, need be but a simple pin. The arm, *h*, is displaced to one side to make the drawing clearer.

shoulders or pins on the record lever in the proper positions. Such brief intervals are, however, hardly useful except in special cases.

The auxanometric lever should work easily and smoothly, and truly in a vertical plane. This may be accomplished in a manner devised by Professor Herbert M. Richards, who kindly allows me to incorporate the idea in this paper. A U-shaped piece of metal is cut out, and the ends of the legs are bent to a J-form. These serve as beds for pieces of capillary, or very heavy-walled glass tubing which function as "hole-jewels" for the pivot of the recording lever. This pivot may be made of a thinnish needle, preferably a long one. Placing the "hole jewels" on the pivot, they are bedded into the J-shaped arms by means of shellac or, better, sealing-wax, and adjusted so as to give as little end-shake to the lever as will allow it to work freely. The lever and its support are then a simple piece of apparatus which may be held in place by means of a clamp. The clamp may be easily improvised, a gravel-filled box or bottle serving as a foot, or a retort stand may be used.

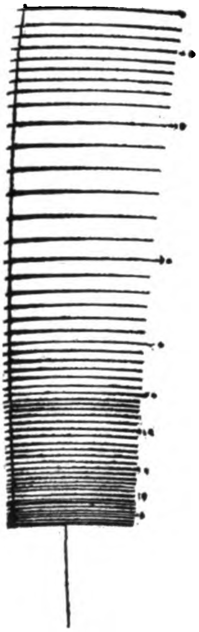

FIG. 3. Record of growth of *Vicia Faba* seedling. The dots opposite the marks indicate six-hour intervals, beginning at 6 P. M., May 14, 1903. The decrease and irregularity in growth after the first 24 hours was due to unfavorable conditions.

The recording pen is very satisfactory if made of sheet celluloid, which may be appropriately bent so as to scratch lightly on smoked paper or mica, attached to the lever actuated by the arm on the clock. Mica is especially good because it does not warp if carefully smoked and may be used in making sun-prints. The record reproduced in the accompanying figure was made in such a way. Some pieces of bent tin serve to make a holder for the recording surface or it may be attached simply by thumb tacks.

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A SUMMARY OF OUR PRESENT KNOWLEDGE (THE FERNS OF THE PHILIPPINES

BY LUCIEN MARCUS UNDERWOOD

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A Summary of our Present Knowledge of the Ferns of the Philippines

By Lucien Marcus Underwood

Linnaeus included a single fern from the Philippines in the first edition of his *Species Plantarum*. This was called *Adiantum Philippense* and was based on a figure of Petiver, who seems to be the sole authority for the source of the fern. Hooker referred the plant with some hesitation to *A. caudatum*, which appears to be a common species in the islands. The early European travelers collected a few ferns in the Philippines, some of which were described by Cavanilles early in the last century; the types of these species are presumably at Madrid. Chamisso included the Philippines in his travels and Kaulfuss described several Philippine ferns in his *Enumeratio* (1824). Presl described a number collected by Thaddeus Haenke and by Née in his *Reliquiae Haenkeanae* (1830) and others still from the same collectors in *Epimeliae Botanicae* (1849). Gaudichaud also visited Luzon and collected a few species. It was not, however, until 1836–40 that any considerable collection was made in the islands, when Hugh Cuming, an English botanical traveler, visited the Philippines and brought back an extensive collection of ferns which were studied by John Smith, of Kew Gardens. Smith published a list of these ferns * which included 297 species, of which he estimated that 100 were new to science. He gave names to his new species but they remained *nomina nuda* until they were described in part by Hooker in *Species Filicum* (1844–1866), and in part by Presl in his *Hymenophyllaceae* (1843) and in his *Epimeliae Botanicae* (1849) and other works. The types of these species are therefore divided between the Royal Herbarium at Kew and the herbarium of the Deutsches Botanisches Institut at Prague. The most complete series of Cuming's collections is at Kew, but extensive duplicate series exist in other herbaria. The types of Haenke's collections are at Prague, where Presl's rich fern collection exists, unmounted, just as its founder left it. A few ferns were collected by Vidal and included in his *Revisión* (1886), and his *Catálogo* (1892) both printed at Manila, but these works contained no additions to the fern flora and their determinations are to say the least of doubtful value.

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* Smith, John. Enumeratio Filicum Philippinarum. Jour. Bot. 3: 392–422. 1841.

More important were the collections of Professor J. B. Steere, of Michigan University, who visited the islands between 1870 and 1875. The ferns of the Steere collection were worked over at Kew by M. W. Harrington,* who described a few species as new and made numerous additions to the known flora. The originals of the Steere collection are at Michigan University and a fair series of duplicates is at Kew.

A still more important collection of Philippine ferns was made in the years 1890–97 by A. Loher, a Bavarian traveler, which was almost as extensive as the earlier one of Cuming. Dr. H. Christ,† of Basel, studied Loher's collection, and his enumeration comprises 271 species, including many additions to the known flora and a number of new species.

Finally Herr O. Warburg, who has for years made a special study of the flora of the monsoon region, traveled in Luzon and the southern portion of Mindanao and made extensive collections. His ferns were studied by Dr. Christ and are listed in the first volume of *Monsunia*,‡ where Dr. Warburg has also given an exended revision of the species of *Selaginella* of the entire Indo-Pacific region from Japan to Australia. Many species were thus added to the Philippine flora, including quite a number of new species, especially in *Selaginella*.

The fern flora of the Philippines as known to-day embraces over 600 species, and it may be said that collection has only commenced. It is probable that when the area is fully explored the extensive archipelago so lately come into our possession will yield at least half as many more species. In order to furnish our botanical residents and travelers in the Philippines a means of understanding the relations of the fern flora of these islands, at least generically, we have prepared the following synopses of the genera known to exist in the islands, which include many forms widely different either from our own temperate ferns, or even from the ferns of the American tropics. The generic sequence here adopted will be found to differ widely from the treatment given in Hooker and Baker's *Synopsis Filicum* (1874), which unfortunately remains the only hand manual of the ferns of all lands and whose treatment of genera is as irrational as its recognition of specific distinctions is defective, generalized and indefinite. The system here adopted will accord more nearly with the treatment by Dr. Diels in *Die natürlichen Pflanzenfamilien*, which in the main is admirable, suffering lapses to the older system mainly in its treatment of the Cyatheaceae and the genera included under *Polypodium* and *Nephrodium*. In the Hymenophyllaceae we have followed in part the admirable treatment of Presl * which, in the main, was taken up by Van den Bosch, the only other monographer who has made a special study of the group, and which has been as systematically neglected by Hooker and Baker and by Sadebeck, who prepared this family for *Die natürlichen Pflanzenfamilien*. For convenience, references are here made to the *Synopsis Filicum* and *Die natürlichen Pflanzenfamilien*, where the treatment differs from either of the works named.

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* Harrington, M. W. The Tropical Ferns collected by Professor Steere in the years 1870–75. Jour. Linn. Soc. **16**: 25–37. 1877.

† Christ, H. Filices Insularum Philippinarum. Bull. Herb. Boiss. **6**: 127–154, 189–211. *pl. 2–4*. 1898.

‡ Warburg, O. Monsunia, Vol. I, 1900. Filicinae, by H. Christ, pp. 54–94. *pl. 2*; Rhizocarpaceae, Equisetaceae, Lycopodiaceae and Selaginellaceae, by O. Warburg, pp. 95–136. *pl. 3, 4*.

While the fern flora of the Philippines is only partially known, it is probable that there will be very few additions to the genera as the result of further exploration. With the exception of the Isoetales — usually the last pteridophytes to be collected in any region — all the orders are represented in the Philippine flora and among the Filicales all the families except the rare and unique Matoniaceae; from the known distribution of the two diverse species of this family it is not improbable that it will ultimately find a representative in our domain. Since the present synopsis is intended chiefly to aid in distinguishing generically the ferns that may be collected in the islands, suggestions are given here and there relative to special points to be noted in the field, since in many genera certain portions of the plant show more important

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1-12. * Presl, C. B. Hymenophyllaceae. Eine botanische Abhandlung. 1–70. *pl.* Prag, 1843.

diagnostic characters than others and need to be specially noted in the field, particularly in plants too large to be collected entire. A few general features should always be noted and these are here summarized:

1. In all ferns not over two feet high an entire plant should be secured, but in plants growing in dense crowns the rootstock may well be split lengthwise and several of the leaves removed before drying.

2. In all ferns not over four feet high an entire leaf should be secured if possible attached to the rootstock or to some portion ot it. In case of very wide leaves the lower pinnae on one side may be cut away to prevent the too great massing of foliage when the leaf is doubled on itself to make a manageable specimen.

3. In tree-ferns the basal portion of the petiole should always be secured, if possible, attached to the lower pinnules. Where possible the top of the caudex should also be taken. Notes on the character of the leaf-scars should always be made.

4. If the specimen taken does not show whether the leaves are scattered or cespitose this fact should always be included in the notes.

5. In ferns of whatever size, invariably secure some portion of the rootstock, for it nearly always possesses diagnostic characters.

6. In large leaves note whether the lowermost pinnae are larger than the others or are reduced in size and if their laminae stand in the same plane as the rest of the leaf or are set obliquely.

Had the earlier collectors followed such directions instead of taking mere tips of large leaves, or single leaves of smaller ferns wholly without rootstocks, we would now be saved the uncertainty of identifying plants with descriptions based on such scrappy materials.

The six orders represented in the Philippines may be distinguished as follows:

1. Plants of fern-like habit, mostly with broad leaves. 2.
Plants of rush-like habit; foliage reduced to whorls of united scales forming sheaths at the joints of the stems; sporangia borne under peltate shields collected in a terminal cone V. **Equisetales.**
Plants of moss like habit, with 4–10-ranked scale-like or linear leaves, terrestrial or epiphytic; sporangia borne in the axils of ordinary or modified leaves. VI. **Lycopodiales.**

2. Homosporous (spores uniform); all terrestrial or epiphytic except *Ceratopteris*. 3.
Heterosporous (producing minute microspores and larger macrospores); aquatic, rooted or floating; sporangia borne in ovoid or spherical conceptacles (*sporocarps*). IV. **Salviniales.**

3. Sporangia on the under surface of the leaf, borne in boat-shaped or circular conceptacles (*synangia*); eusporangiate; vernation circinate. II. **Marattiales.**
Sporangia borne in sori directly on the veins or exceptionally in spikes or panicles. 4.

4. Vernation erect or inclined; eusporangiate, the sporangia ringless, leathery, opening by a transverse slit, arranged in spikes or panicles. I. **Ophioglossales.**
Vernation circinate; leptosporangiate, the sporangia membranous, usually provided with a ring which opens elastically. III. **Filicales.**

I. OPHIOGLOSSALES

The fleshy plants of this order making up the single family Ophioglossaceae are arranged in four genera.

1. Terrestrial plants. 2.
Epiphytic, pendent from trees; leaf strap-like, bearing a spike near the middle. OPHIODERMA.

2. Sporangia in two-ranked spikes; leaves simple; veins anastomosing. OPHIOGLOSSUM.
Sporangia in panicles; leaves compound; veins free. 3.

3. Panicles lax, the sporangia 2-ranked. BOTRYCHIUM.
Panicles close, spike-like; the sporangia clustered and crested. HELMINTHOSTACHYS.

The members of this family are mostly small plants and the species of *Ophioglossum* especially would be likely to be overlooked. Four species of *Ophioglossum* are already known and the other genera are each represented in the islands by a single species. *Ophioderma* has leaves a yard or more long; it is often united to *Ophioglossum*, but in both habit and structure it is abundantly distinct.

II. MARATTIALES

The members of the tropical family Marattiaceae are mostly large fleshy plants with stout stems rising from ponderous corm-like trunks. There are three genera known from the Philippines:

1. Leaves ternate or palmate; synangia circular, depressed in the center. KAULFUSSIA.
Leaves pinnately compound; synangia oval or boat-shaped. 2.

2. Capsules concrete in boat-shaped synangia. MARATTIA.
Capsules close but not concrete, collected in oval sori. ANGIOPTERIS.

Kaulfussia is represented by a single small species with leaves resembling those of the horse-chestnut. *Marattia* has two with bipinnate or tripinnate leaves eight to fifteen feet long, while *Angiopteris* has four nominal species * nearly as large.

III. FILICALES

The ferns proper with circinate vernation belonging to the leptosporangiate series are represented in the Philippines by several families distinguished as follows:

1. Sporangia opening longitudinally, paniculate (or in *Lygodium* borne singly and covered by scales on narrow projections from the leaves). 2.
   Sporangia sessile, borne on a special marginal thread-like receptacle, surrounded by a cup-shaped or bivalved involucre; texture translucent. 7. HYMENOPHYLLACEAE.
   Sporangia dorsal or marginal, attached directly to the lamina, usually collected in definite sori. 3.
2. Sporangia nearly globose with a rudimentary ring. 1. OSMUNDACEAE.
   Sporangia pyriform with an apical ring. 3. SCHIZAEACEAE.
3. Aquatic; leaves dimorphous; sporangial ring broad or rudimentary. 2. CERATOPTERIDACEAE.
   Terrestrial or epiphytic; sporangial ring complete, vertical. 4.
4. Sporangia sessile, wedge-shaped, radially arranged; stems simple or (in all Philippine species) pseudo-dichotomous. 4. GLEICHENIACEAE.
   Sporangia sessile or short-stalked in rounded sori; usually arborescent. 5. CYATHEACEAE.
   Sporangia usually long-stalked; herbaceous, rarely with an arborescent caudex. 6. POLYPODIACEAE.

To the above families belong the largest number of the ferns not only of the Philippines but of the entire world. While the greater part of the Philippine ferns bear a general resemblance to those of temperate regions there are many curious forms particularly among the epiphytic species that are quite unique and widely different from our ordinary conception of a fern. The two families Gleicheniaceae and the tree-ferns (Cyatheaceae) are not represented in temperate America at all, and the filmies (Hymenophyllaceae), rare with us, are abundantly represented in the Philippines as in all tropical regions.

FAMILY 1. OSMUNDACEAE

This family is represented in the Philippines by a single species of *Osmunda*, though it is quite possible that others may be found.

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* Synopsis Filicum reduces all the forms of *Angiopteris* to a single species, but Presl defined ten, and DeVries and Harting who monographed the family in 1853 recognized sixty! From the fleshy nature of the plants it is a genus that requires field study, and description or even identification from herbarium material is necessarily defective.

FAMILY 2. CERATOPTERIDACEAE

The aquatic *Ceratopteris*, apparently a tropical cosmopolite, is the only known representative of this family.

FAMILY 3. SCHIZAEACEAE

Four genera of this family have been found in the archipelago; they may be distinguished as follows:

1.	Sporangia solitary, covered by scales, arranged on marginal teeth of the leaves; leaves pinnate; stems twining.	LYGODIUM.
	Sporangia in distichous spikes; plants small, erect.	2.
2.	Leaves narrow, simple, grass-like.	3.
	Leaves broader, flabellately forked.	LOPHIDIUM.
3.	Spikes in a penicillate tuft.	ACTINOSTACHYS.
	Spikes in a pinnate cluster.	SCHIZAEA.

The last three genera, which have usually been united under *Schizaea*,* are inconspicuous plants represented in the Philippines by one species each. *Lygodium* is represented by six species which are conspicuous climbing ferns very unlike their single diminutive representative in our Eastern States.

FAMILY 4. GLEICHENIACEAE

This family is well represented in the Philippines by eleven species of *Dicranopteris*; † while this number is nominal it is likely not to be excessive, judging from the diversity of species in other tropical regions. The species are wide-spreading, often forming tangled thickets, and are easily recognized by the pseudo-dichotomous branching. They are very difficult to prepare for the herbarium and the greatest care should be taken to secure representative material, since the apical portions of a branch may be quite unlike the lower part of the same plant. By all means the lowest forking should be included in the specimen.

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[*] In case the members of this alliance are grouped as a single genus it must bear the name *Lophidium*, the oldest available name for a member of this group. The three genera, however, are very homogeneous groups and may best be treated as above.

[†] The § *Mertensia* of Synopsis Filicum has been thought by many, commencing with Willdenow, to be worthy of generic rank, and has often been kept distinct from the typical Australasian species of *Gleichenia*. The name *Mertensia*, however, is not available since there is an earlier *Mertensia* in the Borraginaceae. *Dicranopteris* Bernh. is available for this group and was proposed for what has usually been known as *Gleichenia dichotoma* (*Polypodium dichotomum* Thunb.). *Mecosorus* Hassk. was a later name proposed by its author because of the preoccupation of *Mertensia*.

FAMILY 5. CYATHEACEAE

The tree-ferns of the Philippines do not appear to have been adequately collected, but the same is true of the family everywhere. They are not a suitable subject for ordinary herbarium study and should be specially prepared as already noted above. The characteristic armature or vestiture of the leafstalks should always be secured and if possible a section of the caudex. The genera represented in the Philippines are as follows:

1. Sori marginal; indusium coriaceous, 2-valved; herbaceous species. CIBOTIUM.
   Sori dorsal; tree-ferns. 2.
2. Indusium inferior, cup-shaped. CYATHEA.
   Indusium inferior, half cup-shaped. HEMITELIA.
   Indusium wanting. ALSOPHILA.

Cibotium is represented by *C. Barometz*,* often cultivated in American conservatories, and is not a tree-fern. The other genera form the genuine tree-ferns and include thirteen known species, four in *Cyathea*, eight in *Alsophila* and a single *Hemitelia*.

FAMILY 6. POLYPODIACEAE

The true ferns are the most abundant of any family and form three fourths of the fern flora of the islands, which is their usual proportion. The number of genera is so large that we can best distinguish them in their tribal relations separately:

1. Sporangia scattered over the under surface of the leaf-blade in a uniform layer.† 2.
   Sporangia dorsal or marginal, accumulated in definite sori. 3.
2. Leaves of two sorts; a shield-like basal leaf attached to the surface of the substratum and a furcate spreading one with localized sporangial surfaces. 1. *Alcicornieae.*‡
   Leaves approximately uniform; sporangia covering entire leaves or pinnae. 2. *Acrosticheae.*
3. Sori marginal, continuous or interrupted, covered by a more or less modified portion of the leaf-margin. ‡ 3. *Pterideae.*
   Sori dorsal, or at most submarginal, with or without indusia. 4.

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* Included under *Dicksonia* in *Synopsis Filicum*.

† Certain Dryopterideae with confluent sori may be sought here. *Cf. Polybotrya*, *Anapausia*, *Egenolfia*, etc. Their habit is distinctively aspidioid, and lacks the jointed leaf-stalks of the Acrosticheae.

‡ We propose this tribal name for the "stag-horn ferns," believing their unique habit should separate them from the Acrosticheae with which they have usually been associated. The name comes from *Alcicornium* Gaud. (1826), which is an older name than *Platycerium*.

‡ The indusium is wanting in *Notholaena*.

4. Sori elongate-linear. 5.
Sori round or oval. 7.

5. Sori sunken in grooves. 3. *Vittarieae.*
Sori superficial. 6.

6. Indusium normally present (wanting in *Coniogramme* and *Hemionitis*). 6. *Asplenieae.*

Indusium wanting. Certain anomalous *Polypodieae.*

7. Leaves and primary venation fan-shaped; secondary venation anastomosing; indusium wanting. 7. *Dipterideae.**

Leaves and venation normally pinnate. 8.

8. Indusium superior or wanting. 9.
Indusium inferior, rupturing above the sorus. 10. *Woodsieae.*

Indusium attached internally, opening toward the leaf-margin (wanting in *Monachosorum*). 11. *Davallieae.*

9. Leafstalks jointed at their attachment with the rootstock, leaving definite scars when they separate. 10.
Leafstalks continuous with the rootstock; sori dorsal or terminal on the veins, normally indusiate. 8. *Dryopterideae.*†

10. Indusium wanting; sori dorsal or terminal. 4. *Polypodieae.*
Indusium present; sori near the base of the veins. 9. *Oleandreae.*

Tribe 1. Alcicornieae

This tribe is represented in the islands by two species of staghorn fern (*Alcicornium*), characterized by the cordate basal sterile leaves, and the single species of *Cheiropleuria*, with linear sporophyls and two-lobed foliage. Both are epiphytic ferns.

Tribe 2. Acrosticheae

About five species of *Elaphoglossum* with simple free-veined leaves, and a single species of *Acrostichum* with pinnate leaves and anastomosing veins make up the known representation of this tribe in the Philippines. The dense masses of sporangia spread in a uniform layer over the leaves form a character easily recognized.

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* *Dipteris* in *Synopsis Filicum* was placed in the genus *Polypodium*, with which it has no near alliance, and in *Die natürlichen Pflanzenfamilien* it is placed in the Aspidieae, in which it finds an equally insecure resting place. It is a unique fern without near relations and we place it in a distinct tribe.

† Since *Aspidium* as a generic name must be retired to the oblivion of synonymy, it is desirable that we have a tribal name which is derived from a typical or characteristic genus contained in it. We therefore substitute *Dryopterideae* for *Aspidieae* heretofore in use.

Tribe 3. Vittarieae

The three Philippine genera of this tribe may be characterized as follows:

1.	Leaves narrow, grass-like; sporangia in one or more continuous lines.	2.
	Leaves broader; sporangia in broken lines often following the anastomosing of the veins.	ANTROPHYUM.
2.	Sporangial line medial, single.	MONOGRAMMA.
	Sporangial lines double, marginal or submarginal.	VITTARIA.

Eight nominal species of *Antrophyum*, six of *Vittaria* and one *Monogramma* have been reported from the Philippines. All are epiphytic in habit.

Tribe 4. Polypodieae

Two distinct series are represented in this tribe which normally includes the species lacking an indusium. In one series the sori are linear, in the other they are normally round ranging to oval. The genera may be distinguished as follows:

1.	Sori linear, parallel to the midrib or margin.	2.
	Sori linear, oblique to the midrib; veins anastomosing.	SELLIGUEA.
	Sori round or oval.	5.
2.	Leaves simple.	3.
	Leaves pinnate.	4.
3.	Leaves dimorphous, the sporophyls narrow.	DRYMOGLOSSUM.
	Leaves uniform, the apex contracted and bearing the sporangia.	BELVISIA.*
4.	Sori median, between midrib and margin.	TAENITIS.
	Sori finally covering the entire under surface.	PLATYTAENIA.
5.	Under surface of leaf densely covered with stellate hairs.	CYCLOPHORUS.†
	Under surface smooth or barely scaly.	6.
6.	Veins free.	POLYPODIUM.
	Veins anastomosing.	7.
7.	Basal leaves unlike the sporophyls, forming a nest-like cluster at the base of the plant.	DRYNARIA.
	Leaves normally uniform.	8.
8.	Sori dorsal, confined to the veins.	10.
	Sori dorsal, extending to the parenchyma.	9.
	Sori terminal on the veins and marginal on the leaf; sporophyls contracted; rootstocks much swollen.	LECANOPTERIS.
9.	Leaves pinnate.	PHOTINOPTERIS.
	Leaves pinnatifid with decurrent segments.	DRYOSTACHYUM.

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* *Belvisia* Mirbel, antedates *Hymenolepis* Kaulf. adopted in *Die natürlichen Pflanzenfamilien* for this genus.

† *Cyclophorus* Desv. was perfectly well characterized and typified, and there is no excuse for using the later *Niphobolus* Kaulf.

10. Areolae regular, with a single free included veinlet which is directed outward. GONIOPHLEBIUM.*

Areolae small, irregular, with free veinlets spreading in various directions. PHYMATODES.*

Selliguea, joined with *Gymnogramme* in *Synopsis Filicum*, and united with *Polypodium* in *Die natürlichen Pflanzenfamilien*, is represented by eight species. *Drymoglossum*, *Dryostachyum*, *Taenitis* and *Platytaenia* have each a single representative in the Philippine flora, the last two in fact being monotypic genera.

Belvisia, included under *Acrostichum* in *Synopsis Filicum*, has two representatives. The remaining genera recognized above form a part of the unnatural genus *Polypodium*, as recognized in *Synopsis Filicum*. *Lecanopteris* and *Photinopteris* are represented each by a single species; *Cyclophorus* has sixteen nominal species, though not all reported have been taken up by Giesenhagen in his admirable monograph of the genus. This, however, is not an exhaustive treatment from a strictly taxonomic standpoint, containing some new things not properly correlated with that which is old. *Drynaria* similarly has ten nominal species, but the genus has never had a careful revision and all the species require very careful study afield. *Goniophlebium* has four species including the peculiar simple-leaved *Polypodium nummularium* on which Presl based his genus *Crypsinus* perhaps with good reason. *Polypodium* and *Phymatodes* have the largest representation in the islands, the former with nineteen nominal species and the latter with thirty-eight. It is probable that both these genera will receive extensive additions, particularly among the smaller epiphytic species that from their habitat longer evade detection. Such at least has been the experience in other tropical regions. Taken as a whole this tribe is one of the largest as well as one of the most characteristic groups of the Philippine fern flora.

Tribe 5. Pterideae

Maidenhair ferns are apparently less common in the Philippines than in most tropical regions and the entire tribe to which they belong with the exception of a single genus has a comparatively slight representation in the island flora. The several genera may be distinguished as follows:

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* The above synopsis follows exactly the lines noted in *Die natürlichen Pflanzenfamilien*, except that *Goniophlebium* and *Phymatodes* are there included under *Polypodium*, where in our judgment less attention has been given to venation than elsewhere in the work.

1.	Sporangia attached to the under surface of marginal lobes; leafstalks black and shining.	ADIANTUM.
	Sporangia rising from a marginal vein-like receptacle.	2.
	Sporangia rising from the ends of unconnected veins; sori continuous or interrupted.	5.
2.	Indusium double, the inner membranous, extrorse.	3.
	Indusium single.	4.
3.	Leafstalks with several fibrovascular bundles.	PTERIDIUM.
	Leafstalks with a single semicircular fibrovascular bundle.	PAESIA.
4.	Spores sphaero-tetrahedral.	PTERIS.[*]
	Spores bilateral; leaves glaucous with auricled pinnae.	HISTIOPTERIS.
5.	Leaves uniform.	6.
	Leaves dimorphous.	8.
6.	Indusium continuous; stems black, polished.	DORYOPTERIS.
	Indusium interrupted.	7.
	Indusium wanting.	NOTHOLAENA.
7.	Sori distant in sinuses of leaf.	HYPOLEPIS.
	Sori crowded, more or less confluent.	CHEILANTHES.
8.	Leaves simply pinnate.	PLAGIOGYRIA.
	Leaves decompound.	ONYCHIUM.[†]

Of the above genera *Paesia* and *Histiopteris* are each represented by a single Philippine species, *Onychium*, *Pteridium*, *Doryopteris*, *Hypolepis*, and *Notholaena* by two each, and *Cheilanthes* and *Plagiogyria* by three each. *Adiantum* has six representatives, of which one and possibly two are introduced species, while over twenty species of *Pteris* have been reported. The latter genus, and particularly its larger species, require careful field study; the peculiar tripartite branching of the larger species should be specially noted.

Tribe 6. Asplenieae

Next to the Polypodieae this tribe forms the most extensive portion of the Philippine fern flora; the thirteen genera represented may be distinguished as follows:

1.	Sori parallel to the midribs.	2.
	Sori oblique to the midribs.	5.

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[*] We have taken up *Pteris* as treated by Diels, *l. c.*, including species with both free and anastomosing veins. These have been separated by Presl and others, and further study will doubtless prove that they were correct.

[†] Diels following Prantl unites this with *Cryptogramma*, for which we can see no valid reason.

2. Indusium wanting; plants climbing; leaves dimorphous. STENOCHLAENA.
Indusium present; plants mostly terrestrial. 3.

3. Leaves uniform. 4.
Leaves dimorphous; sori intramarginal; caudex sometimes arborescent. STEGANIA.[*]

4. Veins anastomosing between the sori and the margin. WOODWARDIA.
Veins free between the sori and the margin. BLECHNUM.

5. Indusium wanting. 6.
Indusium present. 8.

6. Veins free. 7.
Veins anastomosing. HEMIONITIS.[†]

7. Sori forked, with the forking of the veins. CONIOGRAMME.[‡]
Sori simple, linear. SYNGRAMMA.[‡]

8. Veins free. 9.
Veins anastomosing. 10.

9. Sori confined to one side of a vein, linear or slightly curved. ASPLENIUM.[§]
Sori curved or horseshoe-shaped, crossing to both sides of the veins. ATHYRIUM.[§]
Sori double, the indusia opening on both sides of some of the veins. DIPLAZIUM.
Sori rising from a special receptacle midway between veins; indusia attached to the veins, opening toward each other. TRIPHLEBIA.

10. Veins connected only at their apices; leaves simple, densely clustered. THAMNOPTERIS.[‖]
Veins forming regular areolae. CALLIPTERIS.[¶]

Woodwardia, *Hemionitis* and *Coniogramme* are each represented in the Philippines by a single species, *Triphlebia* and *Syn-*

---

[*] Diels unites this with *Blechnum*, although under the name *Lomaria* the genus is held as distinct even in *Synopsis Filicum*. The name *Struthiopteris* must hold for the European and North American representative of the genus (*S. Spicant*) and *Lomaria* had for its type a member of another genus, so must be replaced by *Stegania* R. Br., if generic distinctness from the North Temperate representatives is maintained.

[†] *Hemionitis* is associated in *Die natürlichen Pflanzenfamilien* with the Pterideae, with which it appears to have no near relationship; it must either form a tribe by itself or be associated here with its nearest but not very close allies.

[‡] *Coniogramme* and *Syngramma* form a part of the heterogeneous *Gymnogramme* of *Synopsis Filicum;* Diels associated them with the Pterideae, for which we can see no warrant.

[§] It is still an open question as to what we shall consider the generic types of these two genera; they are adopted here tentatively in their usually accepted sense.

[‖] The "bird's nest fern"; united with *Asplenium* by both Diels and Baker.

[¶] The earlier name for *Anisogonium* Presl. Diels unites it with the free-veined *Diplazium* and both are joined as sections of *Asplenium* in *Synopsis Filicum*. *Allantodia* of *Synopsis Filicum* is also reported from the Philippines, but the name cannot hold for the species to which it is assigned and the genus is not clearly distinguished from *Callipteris*.

gramma by two each, *Stenochlaena*, *Thamnopteris* and *Athyrium* by four each, *Stegania* by five, and *Blechnum* by six ; the larger genera are *Callipteris* with twelve species, *Diplazium* with twenty-one, and *Asplenium* with thirty-three. These numbers, however, represent nominal species and yet are not likely to be much reduced, and will be varied only by future discoveries.

Tribe 7. Dipterideae

This tribe is represented only by a single species of the curious fan-shaped *Dipteris*, perhaps one of the most unique among the ferns of the islands. Its leaves are often two or three feet broad.

Tribe 8. Dryopterideae

Related to our wood-ferns are a large number of species in all tropical regions and the Philippines come in for their share. The sixteen genera are distinguished as follows:

1. Veins normally free, simple, forked, or pinnately branched. 2.
Veins connivent, *i. e.*, the branches from contiguous pinnate groups uniting to form one or more arches. 4.
Veins copiously anastomosing. 6.

2. Leaves dimorphous; sori extending from the veins to the parenchyma so as to appear continuous. 11.
Leaves uniform or nearly so. 3.

3. Indusium wanting; margins of segments plane. PHEGOPTERIS.
Indusium circular, peltate. 8.
Indusium oval, attached by a central axis to a thickened linear receptacle. DIDYMOCHLAENA.
Indusium cordate-reniform, attached by the sinus; veins distinct. DRYOPTERIS.

4. Indusium wanting. 5.
Indusium cordato-reniform, attached by the sinus. CYCLOSORUS.

5. Sori round, punctiform. GONIOPTERIS.
Sori elongate on the more or less parallel transverse arches. MENISCIUM.

6. Indusium wanting. 7.
Indusium cordato-reniform, attached by the sinus. 9.
Indusium orbicular, centrally peltate. 10.

7. Leaves dimorphous; sori extending to parenchyma so as to appear continuous. 12.
Leaves uniform. ARCYPTERIS.*

---

* The genus *Dictyopteris* Presl (1836) is antedated by a genus of the same name among the algae. We therefore propose the name **Arcypteris,** with the same meaning. It is not the exact equivalent of *Dictyopteris* Presl, the first species of which was *Polypodium attenuatum* R. Br., which does not belong to the § *Dictyopteris* as taken up by *Synopsis Filicum*. *Aspidium difforme* Blume (Enum. Pl. Jav. 160. 1828) may be considered as the type of *Arcypteris*.

8. Pinnae continuous with the rachis; texture firm, more or less coriaceous. POLYSTICHUM.

Pinnae articulated with the rachis, easily caducous; texture thin herbaceous. CYCLOPELTIS.

9. Areolae irregular, without free veinlets. PLEOCNEMIA.

Areolae provided with free recurrent veinlets. SAGENIA.

10. Areolae regular; included veinlets straight, directed towards the margins of the segments. CYRTOMIUM.

Areolae irregular, fine; included veinlets often branched and recurrent. TECTARIA.

11. Rootstock short. EGENOLFIA.

Rootstock widely climbing. POLYBOTRYA.

12. Areolae few, without free included veinlets. STENOSEMIA.

Areolae copious, with free included veinlets. ANAPAUSIA.*

The disposition of these genera by Hooker and Baker and by Diels is so diverse that it can be best represented in tabular form:

Genera here accepted	Number of Philippine species reported	Equivalent genera in *Die natürlichen Pflanzenfamilien*	Equivalent genera in *Synopsis Filicum*
Phegopteris	9	Nephrodium	Polypodium
Polystichum	9	Polystichum	Aspidium
Cyclopeltis	1	Cyclopeltis	Aspidium
Didymochlaena	1	Didymochlaena	Didymochlaena
Dryopteris	44	Nephrodium	Nephrodium
Cyclosorus	24	Nephrodium	Nephrodium
Goniopteris	6	Nephrodium	Polypodium
Meniscium	2	Nephrodium	Meniscium
Arcypteris	5	Nephrodium	Nephrodium
Pleocnemia	5	Nephrodium	Nephrodium
Sagenia	9	Aspidium	Nephrodium
Cyrtomium	1	Polystichum	Aspidium
Tectaria	7	Aspidium	Aspidium
Egenolfia	1	Polybotrya	Acrostichum
Polybotrya	5	Polybotrya	Acrostichum
Stenosemia	1	Stenosemia	Acrostichum
Anapausia	12	Gymnopteris	Acrostichum

Tribe 9. Oleandreae

This tribe is represented in the Philippines by four nominal species of *Oleandra*, the only genus in the tribe. Their satiny luster renders them peculiarly attractive among ferns.

Tribe 10. Woodsieae

This tribe is represented in our eastern possessions only by one species of *Diacalpe*.

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*These have been usually placed in *Gymnopteris*, but that genus was monotypic as originally founded and based on a plant of a wholly different alliance.

Tribe 11. Davallieae

The eight genera represented may be distinguished as follows:

1. Pinnae one-sided: indusium double, the inner membranous, the outer formed of the more or less changed leaf-margin. LINDSAEA.
Pinnae developed on both sides of midrib, though not always equally. 2.

2. Indusium attached only at base. 3.
Indusium attached on three sides. 4.
Indusium wanting; sori subterminal on the veins. MONACHOSORUM.

3. Pinnae jointed to the rachis. NEPHROLEPIS.
Pinnae not jointed; leaves jointed to the rootstock. HUMATA.
Pinnae not jointed; leaves not jointed to the rootstock. SACCOLOMA.

4. Leaves jointed to the rootstock. DAVALLIA.
Leaves not jointed to the rootstock. 5.

5. Leaf-lobes as long as indusium and both uniting in a special cup beneath the sorus. DENNSTAEDTIA.
Leaf-lobes slightly modified, longer than the indusium. 6.

6. Sorus with a receptacle containing tracheids; leaves scattered on a creeping rootstock. MICROLEPIA.
Sorus without a tracheidal receptacle; leaves clustered. ODONTOSORIA.

The Malaysian region is the home of certain groups of the davallioid ferns; *Humata* is represented by twelve species; *Davallia* also by twelve species, of which six belong to the § *Odontoloma*, sometimes recognized as a genus; *Odontosoria* by a single species, and *Microlepia* by nine; all the foregoing are included in the genus *Davallia* in *Synopsis Filicum*. Of the other genera *Nephrolepis* has eight nominal Philippine species, a number which may be modified, since the genus is sadly in need of a revision; *Lindsaea* has seventeen, *Dennstaedtia* has four, and *Monachosorum* and *Saccoloma* each one.

FAMILY 7. HYMENOPHYLLACEAE

Following the usual treatment the filmy ferns are grouped in two genera representing the primary divisions in the following synopsis. We believe, however, that many of the genera established by Presl are as clearly marked natural groups as can exist among the ferns, and in the following treatment we have taken up such of Presl's genera as occur in the Philippines, believing that others represented in tropical America and elsewhere represent equally natural groups.

The Philippine genera are as follows:

1. Indusium tubular; receptacle filiform exserted. (*Trichomanes* Syn. Fil.) 2.
Indusium 2-valved, formed of two divided laminae of the leaf; receptacle shorter than the indusium or barely protruding. (*Hymenophyllum* Syn. Fil.) 6.

2. Margin of the indusium entire. 3.
Margin of the indusium 2-lipped. 5.

3. Receptacle terminating in a rounded head. CEPHALOMANES.[*]
Receptacle uniformly terete. 4.

4. Leaves and indusia bordered by rows of minute cells. ABRODICTYUM.[†]
Leaves of uniform texture not bordered. TRICHOMANES.

5. Indusium contracted below the lips, bordered by the tissue of the leaf. DIDYMOGLOSSUM.[‡]
Indusium lateral, subpedicellate, not contracted nor bordered. MERINGIUM.[§]

6. Receptacle clavate; leaves smooth; sporangia sessile. HYMENOPHYLLUM.
Receptacle globose-thickened at the summit; leaves often covered or margined with simple or stellate hairs, sometimes smooth; sporangia stipitate. SPHAEROCIONIUM.[||]

Of the above genera *Cephalomanes*, *Abrodictyum*, and *Meringium* are each represented by a single species, *Sphaerocionium* and *Didymoglossum* by six each; *Hymenophyllum* still has a residue of fourteen species, and *Trichomanes* a still larger one of twenty-four. There has been no modern monograph of this family, so that these numbers are likely to be varied greatly aside from future additions to the flora.

IV. SALVINIALES

Both families of this order are represented in the Philippines: the floating Salviniaceae by a single species of *Azolla*, and the rooting Marsileaceae by a single species of *Marsilea* with the usual quadripartite foliage characteristic of the genus. The species of *Marsilea* grow in wet places and often resemble in habit small plants of *Oxalis.*

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[*] *Cephalomanes* Presl, Hymenophyllaceae, 17. *pl. 5.* 1843. Monotypic; based on *C. atrovirens* Presl (Luzon, *Cuming, no. 169*); there was evidently a mixture in this number, for Hooker in commenting on Presl's genera says that his plant under that number is *Trichomanes Javanicum*. Presl later defends his genus in vigorous language and adds other species, and the genus was accepted by Van den Bosch.

[†] *Abrodictyum* Presl, Hymenophyllaceae, 20. *pl. 7.* 1843. Monotypic; based on *A. Cumingii* Presl (Luzon, *Cuming, nos. 208, 358*).

[‡] *Didymoglossum* Desv. Ann. Soc. Linn. Paris, 6: 330. 1827. Based on *Trichomanes muscoides* Sw. (first named) and seven other species.

[§] *Meringium* Presl, Hymenophyllaceae, 21. *pl. 8, f. B.* 1843. Based on two species, of which *M. Meyenianum* Presl (Luzon, *Meyen*) is named as type.

[||] *Sphaerocionium* Presl, Hymenophyllaceae, 33. *pl. 4, f. B; pl. 10, f. B, C.* 1843. Based on *Hymenophyllum hirsutum* Sw. (first named) and numerous other species.

V. EQUISETALES

This order of a single family has at present one known representative in the Philippines, *Equisetum debilis*, also found in southeastern Asia.

VI. LYCOPODIALES

All three of the families of this order are represented in the Philippines. They may be easily recognized as follows:

1.	Spores minute, of one sort.	2.
	Spores of two sorts, minute microspores and larger macrospores; leaves (in all Philippine species) 4-ranked, of two sizes.	3. SELAGINELLACEAE.
2.	Sporangia unilocular.	1. LYCOPODIACEAE.
	Sporangia 2–3-locular.	2. PSILOTACEAE.

The Lycopodiaceae are represented by thirteen species of *Lycopodium*, two of which are said to be species of the temperate or subboreal region of the United States, a statement which appears scarcely credible.

The Psilotaceae are represented by *Psilotum nudum* with leaves reduced to mere rudiments, and trilocular sporangia, and *Tmesipteris Tannensis* with oval leaves nearly an inch long and bilocular sporangia. The Selaginellaceae are represented by thirty-three species of *Selaginella*, the larger part of which have been added through the labors of Dr. Warburg.

SUMMARY

Orders	*Families*	*Genera*	*Species*
Ophioglossales	1	4	7
Marattiales	1	3	7
Filicales	7	91	568
Salviniales	2	2	2
Equisetales	1	1	1
Lycopodiales	3	4	48
Totals	15	105	633

The fern flora of the Philippines is evidently related on the one hand to that of Formosa and the Asiatic continent, and on the other to that of the more southerly islands of Celebes and Borneo; the extensive recent additions to the fern flora of the latter island through the discoveries of Bishop Hose open up a series of interesting distributional problems relative to the southern islands of the Philippine group which have never yet been explored botanically. It is hoped that some American residents in the Philippines will become interested in the ferns of the islands and make extended studies of their interesting pteridophyte flora. We shall be only too glad to render any assistance in specific identification that may be sought in the hope that our knowledge of the fern flora of this prolific region may be thereby extended.

COLUMBIA UNIVERSITY, 1 November, 1903.

Since the above article was in print I have learned of the publication of a paper by Mr. E. D. Merrill on the botanical work already accomplished in the Philippines, said also to give an account of the existing herbaria in the archipelago.—L. M. U.

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The Memoirs already published are:—

Vol. I. **Small.** A Monograph of the North American Species of the Genus *Polygonum.* Pp. 178. 84 plates. 1895. Price, six dollars.

Vol. II. **Rydberg.** A Monograph of the North American Potentilleae. Pp. 224. 112 plates. 1898. Price, six dollars.

The Contributions have now reached the ninth volume.

Vol. I. Nos. 1–25 (1886–1892). Out of print, except Nos. 6, 7, 11, 13, 17, 20, 21, 22, 24. These can be supplied at twenty five cents each, except No. 6, which is one dollar.

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* Nos. 157 and 158, with the set of nine papers by Mr. Bicknell on *Sisyrinchium*, can be had for one dollar and fifty cents.

Lists of titles of Contributions may be had on application.

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CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 207

EXPLORATIONS IN THE COASTAL PLAIN OF GEORGIA DURING THE SEASON OF 1902

By ROLAND M. HARPER

NEW YORK
1904

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 31 : 9–27. January, 1904.]

Explorations in the coastal plain of Georgia during the season of 1902

ROLAND M. HARPER

My explorations in Georgia in 1902, beginning at Augusta on June 5 and ending near the same place on November 16, were confined to those counties lying wholly or partly in the coastal plain. Notes and collections were made in the counties of Columbia (nos. *1294–1302*, *1310–1314* *), Richmond (*1303–1309*, *1315–1321*), Burke, Jefferson, Glascock (*1322–1326*), Washington (*1327–1331*), Johnson (*1332–1347*), Laurens (*1348–1373*), Dodge, Pulaski (*1374–1387*), Wilcox, Dooly (*1712*), Sumter (*1388–1406*, *1713–1731*), Marion (*1407–1410*), Schley (*1411–1413*), Irwin (*1414–1422*, *1702–1704*, *1708–1711*), Coffee (*1423–1463*), Appling, Pierce (*1464–1467*), Ware (*1468–1470*), Charlton (*1471–1516*, *1573–1577*), Wayne, Glynn (*1518–1537*), Camden (*1517*, *1538–1572*), Clinch (*1578–1580*, *1583–1585*), Echols (*1581–1582*), Lowndes (*1586–1615*), Brooks (*1616–1633*), Thomas (*1634–1639*), Colquitt (*1640–1676*), Berrien (*1677–1696*, *1699–1701*, *1705–1707*), Worth (*1697*, *1698*), Lee, Terrell, Randolph (*1732–1745*, *1758–1784*), Quitman (*1746–1757*), Clay (*1786–1793*), Webster, Stewart, Chattahoochee (*1794*, *1795*), Muscogee (*1796–1800*), Talbot, Taylor (*1801–1803*), Crawford (*1804*), Houston, Bibb (*1805–1808*), Jones, Wilkinson and Screven, approximately in the order named. Numbers *1294–1387* were collected in June, *1388–1463* in July, *1464–1585* in August, *1586–1701* in September, *1702–1793* in October, and *1794–1808* in November. One hundred and fifty-two numbers of bryophytes and thallophytes, which do not appear in the foregoing enumeration, were also collected.

My travels by rail within the state covered more than 1500 miles, less than 200 of which were the same as had been traversed the previous season. About 400 photographs of the vegetation and scenery were taken.

Whenever opportunity offered special attention was paid to the problem of determining the exact location of the fall-line, or inland boundary of the coastal plain. I ascended the Savannah, Ocmulgee, Flint and Chattahoochee Rivers and Rocky Comfort Creek (the latter in Glascock County) to beyond their intersections with this line, and also followed it pretty closely by rail through the counties of Muscogee and Talbot.

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* Numbers of the plants collected.

Many of the oldest and largest cities of the Middle and South Atlantic States are situated on this fall-line, which usually marks the head of navigation, and in many cases the greatest water-power, on the rivers which cross it. But botanists who have collected around these cities have almost invariably failed to indicate whether their plants came from the hill country above or the coastal plain below. From a phytogeographical standpoint this is a most serious omission, for the fall-line, throughout its length of hundreds of miles, is (in the words of Dr. McGee *) "one of the most strongly marked physiographic and cultural lines on the surface of the globe," and "the most important structural line of eastern United States." The rather vaguely defined "Austroriparian area" of some botanists — or rather biologists — is practically the coastal plain, and the boundary between that and the "Carolinian area" is simply the fall-line, the cause of which is purely geological, and not climatic.

It should not be inferred, however, that the fall-line is always so sharply defined as to be visible in the field at a single glance. On the contrary it cannot usually be definitely located within a mile or two, except along the larger streams. Nevertheless, it seems to be an impassable barrier for many species of plants; and the great difference in aspect of the topography and flora on opposite sides of this line is apparent to the most indifferent observer.

A few places of historical or geographical interest visited on this trip will now be mentioned.

In June I spent a week in the vicinity of Augusta, where the most interesting natural feature, to a botanist at least, is the sand-hills, so well known to winter visitors. These are part of a line of sandy elevations which extend along or near the fall-line from

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* Ann. Rep. U. S. Geol. Surv. 12^1: 356, 357. 1891. The introductory portion of this paper is recommended to the careful consideration of the reader.

central North Carolina to western Georgia, with some interruptions. Little is known of the origin and geological history of these fall-line sand-hills, and they deserve further study. Their flora is of course eminently xerophytic, but need not be discussed here.

Augusta was visited in the eighteenth century by Bartram and Michaux, and in the nineteenth by Baldwin, Croom, Leavenworth, Olney, Ravenel, McCarthy, Sargent, Small and other botanists. It is now the home of Mr. A. Cuthbert, the discoverer of several species new to science, with whom I had the pleasure of comparing notes. The influence of Michaux's work in this vicinity is strikingly shown by the fact that of the flora of these particular sand-hills most of the characteristic species and several of the genera were discovered and described by him.

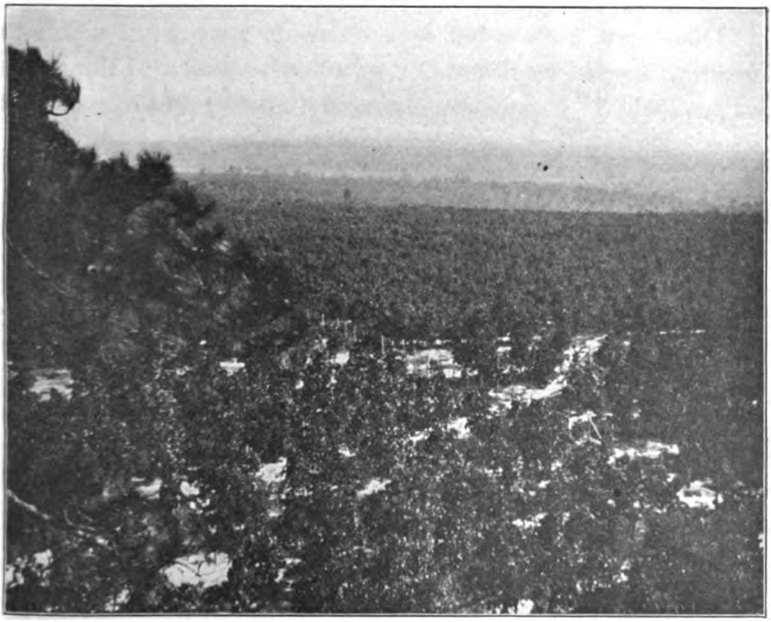

FIG. 1. General view of fall-line sand-hills near Augusta. June 8.

In November I examined other portions of the fall-line sand-hills, in the counties of Talbot, Taylor and Jones. The area in Talbot and Taylor Counties extends about twenty miles east and west and perhaps nearly as far north and south, but is little known.

Here the sand-hills rise to six or seven hundred feet above sea-level and considerably above the adjacent metamorphic hills. They are comparatively level, however, as is well illustrated at Tangent in Taylor County, where the railroad track is straight beyond the horizon in both directions. This region is sparsely settled, and its pine forests still furnish lumber and turpentine in merchantable quantities. The manufacture of turpentine here is of interest because a distance of at least fifty miles, including the whole width of the outcrop of the Eocene formations, intervenes between this and the pine-barren region where the rest of the turpentine of Georgia is now produced.

This western sand-hill area seems to have been first made known to science by Elliott. Bartram, who traversed these counties (or rather the area now included in them) in the summer of 1776, and again the following winter, must have passed just to the north of the sand-hills, for he does not mention them in his *Travels*. Elliott visited them early in the nineteenth century, and discovered there several new species, among them *Chrysopogon secundus*, *Thysanella fimbriata*, *Dicerandra linearifolia* and *Chrysopsis pinifolia*, * all of which I also saw in the same region. Elliott's route was along the "Federal Road," which runs along or near the fall-line and connects the present cities of Macon and Columbus (neither of which existed in Elliott's time).

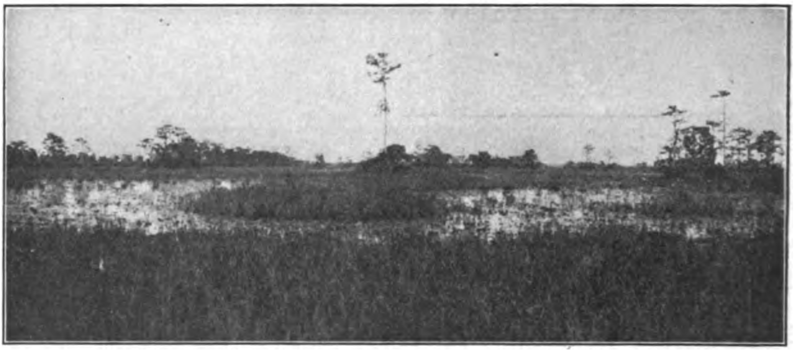

FIG. 2. Open portion of Okefinokee Swamp. August 7.

Since Elliott no botanist seems to have explored these western sand hills except the late Dr. Hugh M. Neisler, who lived for many years in Butler, the county-seat of Taylor County, and sent specimens from there (many of which are now preserved in the Torrey Herbarium) to Dr. Torrey. At Reynolds, in the same county, I met a grandson of Dr. Neisler, who took me to another historic spot, the site of the Indian Agency at the crossing of the Federal Road and Flint River, where Dr. Baldwin spent several weeks in the spring of 1812.* The two species which Dr. Baldwin discovered here I was unable to find. But on the river bank just above the Agency (and at or near the fall-line) I saw growing in intimate association *Hydrangea quercifolia* and *Hypericum aureum*, both of which were discovered within a few miles of this place by Bartram in July, 1776, the former east of the river and the latter west. Both were also noted near the Agency by Dr. Baldwin.

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* See Bot. S. C. & Ga. 1: 580, 583; 2: 94, 335.

In June I explored portions of the sand-hills of the Oconee and Ocmulgee Rivers, opposite Dublin and Hawkinsville respectively. These river sand-hills are probably of a different origin from the fall-line sand-hills, but their flora is similar in composition and almost identical in aspect. Analogous sand-hills occur along the left sides of many other streams in Southeast Georgia, but are rare in Southwest Georgia and seem to be unknown in Alabama.

In August I spent two days (6th to 8th) in Okefinokee Swamp (which is mostly in Charlton County), in company with Mr. P. L. Ricker, of the U. S. Department of Agriculture. Okefinokee Swamp differs materially from the two other great swamps of the eastern United States (Dismal Swamp and the Everglades) in being about 50 miles inland and over 100 feet above sea-level, but it has several features in common with each. No account of the flora of Okefinokee has ever been published, but space will not permit a detailed description here. The swamp, although exceedingly interesting phytogeographically, seemed to contain no endemic species of flowering plants. About 75 species were observed, but this may not be over half the total number in the swamp.

Later in the same month we visited two islands on the neighboring coast, both now favorite summer resorts: St. Simon's, in Glynn County, and Cumberland, in Camden. These islands were visited in the eighteenth century by Bartram and Michaux, but seem to have been untouched in the nineteenth by all botanists except Dr. Baldwin, who visited Cumberland occasionally during the few years of his residence at St. Mary's, on the adjacent mainland. Some portions of Cumberland island rise about 50 feet above sea-level, which is higher than most, if not all, of the other islands along the Georgia coast, and probably as high as any part of the mainland of Camden County. The floras of the two islands are remarkably different, considering their proximity to each other and to the mainland.

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* See Reliq. Baldw. 58–62 *et seq.*

On September 4 I visited two interesting bodies of water in the southern part of Lowndes County, near Lake Park. Ocean Pond, the larger of the two, is said to be about two miles in diameter, and is probably the largest pond in the state. But, strange to say, for over fifty years it has been represented seven or eight miles from its true position on all maps of the state which show it at all. Its water is quite clear and the shore mostly sandy, like that of Open Pond in Decatur County, * which I visited the summer before. Among other interesting plants seen in Ocean Pond and along its shores were *Sagittaria isoetiformis*, *Hydrochloa fluitans*, *Eriocaulon septangulare* (*no. 1608*), *Lachnocaulon Beyrichianum* (*no. 1607*), *Polygonum hirsutum* (*no. 1609*), and *Nymphaea orbiculata* (*no. 1610*).

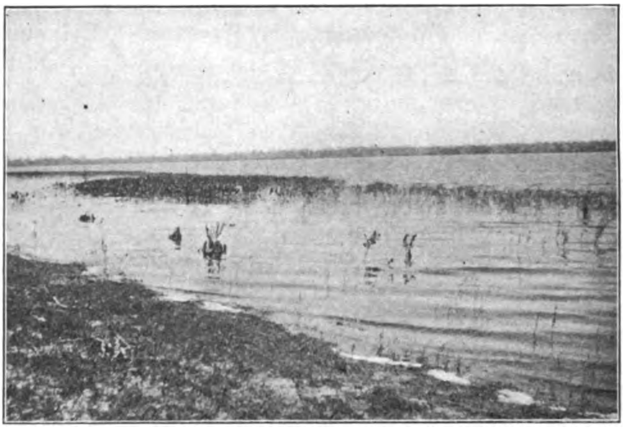

FIG. 3. Ocean Pond, Lowndes County. September 4.

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* See Bull. Torrey Club, 30: 290. My 1903.

Long Pond, about a mile away, is about half as large as Ocean Pond. Its water is also clear, but it has no shore (at least on the side examined), being bordered by a fringe of cypress swamp. It is analogous in many ways to Cane Water Pond in Decatur County.* In Long Pond I collected an apparently undescribed species of *Nymphaea* (*no. 1611*). These two ponds, like the two similar ones in Decatur County, are partly surrounded by dry sandy areas characterized by *Eriogonum tomentosum* and other xerophytes.

Toward the end of the same month I revisited the type locality of *Rhynchospora solitaria* and *Baldwinia atropurpurea*, the two species which I discovered in Tifton two years before. The locality (a characteristic area of primeval moist pine barrens) is so near the center of the city that it is in imminent danger of destruction by the encroachments of civilization, but fortunately both species are common enough elsewhere in the same and adjoining counties.

In October I studied portions of Randolph, Clay and Quitman Counties, in the Cretaceous and Eocene regions, making headquarters at Cuthbert for about three weeks. Cuthbert is one of the oldest cities in southwest Georgia, but seems never to have been visited by a traveling botanist before, though there was resident in the city at that time an enthusiastic amateur, Rev. C. H. Hyde, to whom I am indebted for his hospitality and for guiding me to many interesting places in the vicinity.

Cuthbert, though south of latitude 32°, has an elevation of nearly 500 feet and is several miles outside of the pine-barrens, in a region of red hills not unlike some of those in Middle Georgia. *Pinus palustris* seems to be entirely absent from a considerable area (whose limits have not yet been accurately determined) around Cuthbert and extending through several counties, where *P. echinata* takes its place.

On steep shaded hillsides and in rich ravines in this part of the state, where the original forest has not been destroyed, plants of more northern range abound, and I was continually surprised at finding such species as *Adiantum pedatum*, *Phegopteris hexagonoptera*, *Brachyelytrum erectum*, *Vagnera racemosa*, *Polygonatum biflorum*, *Uvularia perfoliata*, *Trillium erectum*, *Pogonia verticillata*

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* See Bull. Torrey Club, 30: 290. My 1903.

(*no. 1762*), *Sanguinaria Canadensis*, *Actaea alba*, *Xanthorrhiza apiifolia*, *Hydrangea arborescens*, *Viola tripartita glaberrima*, *Dirca palustris* (*no. 1790*), *Panax quinquefolium*, *Kalmia latifolia* and *Phryma Leptostachya*, associated with coastal plain types like *Pinus glabra*, *Rhapidophyllum Hystrix* and *Magnolia grandiflora*. Other very interesting plants were found on the banks of the Chattahoochee River near Georgetown (in the Cretaceous region) and Fort Gaines (Eocene).

On October 23, in company with Mr. Hyde, I visited a cave (known as Grier's Cave), in Randolph County, about ten miles north of Cuthbert. Over several acres around this cave a compact limestone of the Midway or Clayton period (lowest Eocene) crops out in huge boulders and ledges, and supports a deciduous forest containing a great variety of herbs as well as trees. The aspect of the place is much like that of the Mountain Limestone area at the north end of Pigeon Mountain in Walker County,* and some species are common to the two places. An interesting feature of the flora of the rocky woods around Grier's Cave is the large number of plants with barbed fruits, adapted for dissemination by animals. Representatives of at least six families with this adaptation were observed.

The following species of more than ordinary interest were collected or observed in 1902:

ADIANTUM PEDATUM L.

Grows luxuriantly on the steep shady north side of a high bluff along Samochechobee Creek in Clay County, where I collected it on October 28 (*no. 1786*). This locality (in latitude 31° 38′) is, I believe, considerably farther south than any other known for this species, and is the only one known in the coastal plain in Georgia and adjacent states.

ADIANTUM CAPILLUS-VENERIS L.

Very abundant on the perpendicular rocky walls (Eocene) of the same creek near its confluence with the Chattahoochee River just above Fort Gaines. Seen also on the bluff of the river itself at Fort Gaines, and just above Georgetown, where I collected it on overhanging Cretaceous rocks on October 16 (*no. 1756*).

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* See Bull. Torrey Club, 28: 456, 482. 1901.

ERAGROSTIS AMABILIS (L.) Wight & Arn.; Hook. & Arn. Bot. Beechey, 251. 1841

In the BULLETIN for July, 1902, Scribner and Merrill have reported the occurrence of this Asiatic ornamental grass in Middle Florida. In September I found it quite common as a weed along moist roadsides and railroad ditches in the vicinity of Quitman (*no. 1616*) and Moultrie. There is nothing in its mode of occurrence to suggest its having escaped from cultivation (if indeed it has ever been cultivated in that part of the country) and it seems to be thoroughly naturalized.

ERAGROSTIS SIMPLEX Scribn. Bull. Div. Agrost. U. S. Dept. Agric. No. 7, ed. 3, 250. 1900

"*E. Brownei* Nees" of Chapman and several other authors.

A weed of unknown origin which is common along most railroads in South Georgia, especially in the pine-barren region. Collected in Colquitt County, September 22 (*no. 1656*). Previously reported only from Florida.

FIMBRISTYLIS PERPUSILLA Harper; Small, Fl. S. E. States, 188. 1903

Although this species has already been described, it has several peculiarities which could not be mentioned in the limited space of the original description.

The plant was collected (in flower) on the muddy bottom of a dried-up pine-barren pond near Leslie, Sumter County, on the morning of October 9 (*no. 1729*). It was very abundant, but so small as to be scarcely visible to a person standing up. Its only associates visible to the naked eye were two bryophytes, *Riccia Sullivantii* and *Ephemerum tenerum*, the latter almost microscopic. The vegetative period of the *Fimbristylis* must be very brief and irregular, for the pond in which it grows cannot be expected to dry up at the same time every year, and there may be years in which it does not dry up at all.* In this respect our

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*On July 13, 1903, I revisited the type-locality and found it covered by about three feet of water. No trace of the *Fimbristylis* could be found in several handfuls of mud taken from the bottom.

plant is inversely analogous to some species of *Isoetes* (*I. melanospora* and *I. Orcuttii*, for instance), which grow in shallow depressions on rocks and vegetate only in wet seasons.

Fimbristylis perpusilla is one of the smallest and simplest species of the genus, but it is too different from the other species occurring in the vicinity to be regarded as a depauperate form of any of them and besides the specimens were perfectly healthy and vigorous, *F. autumnalis* sometimes finds its way into pine-barren ponds as they dry up in summer or fall, but in so doing it changes none of its characters. A depauperate form of *F. Frankii* (also associated with a *Riccia*) has been found by Mr. A. A. Eaton on muddy shores of a pond in Kingston and East Kingston, N. H., but it is quite different from my plant.

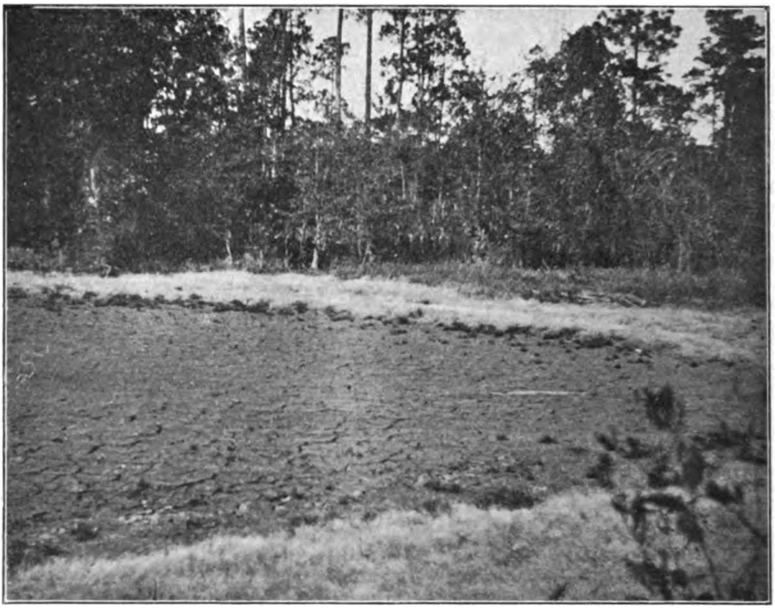

FIG. 4. Type-locality of *Fimbristylis perpusilla*, near Leslie, Sumter County. October 9.

By its floral characters *F. perpusilla* seems nearest related to *F. Vahlii*, but in that species (which is not known in Georgia) the culms are densely tufted and erect or nearly so, and the spikelets are all sessile, while in *F. perpusilla* the culms (8 or 10 to each plant) are prostrate, and of the 3 to 6 spikelets in each umbel some are sessile and some on peduncles 1–4 mm. long. (That part of the original description conflicting with this is erroneous.)

Mr. M. L. Fernald has suggested the resemblance of my plant to *F. dipsacea* (Rottb.) B. & H., an Asiatic species, but this resemblance is probably only accidental. *F. dipsacea* has been treated as the type of a distinct genus (*Echinolytrum* Desv.), on account of some peculiarities of its achenes, which find no parallel in my plant. It should be borne in mind that nearly all the pine-barren plants are endemic species, so that the probability of one of them being identical with an Asiatic species is very small. And there is not the slightest possibility of my plant having been introduced.

RHYNCHOSPORA SOLITARIA Harper, Bull. Torrey Club, **28**: 468. 1901

Collected again at the type-locality in Tifton, September 26 (*no. 1677*); also seen in similar situations in Colquitt County a few days earlier and in Irwin County a few days later. Since seeing this species in the field again I can now indicate its affinities with more certainty. It seems nearest related to *R. ciliaris* (Michx.) Mohr (*R. ciliata* Vahl), from which it differs principally in being more slender and glabrous, with longer erect leaves, narrower spikelets and longer perianth bristles, and in its later flowering period. These two species, together with *R. Baldwinii*, seem to form a small natural group. If my view is correct *R. solitaria* is not a near relative of *R. Tracyi* (which is scarcely a true *Rhynchospora*), which it immediately follows in Dr. Small's Flora.

RHAPIDOPHYLLUM HYSTRIX (Pursh) Wendl. & Drude

This, one of the rarest of our palms, I first found in rich shady woods northwest of Cuthbert, on October 21 (*no. 1769*). Here there were only a few specimens, but a few days later I found it more abundant in similar situations along Samochechobee Creek in Clay County.

This species seems to have been previously known in Georgia only from the type-locality, "near the town of Savannah," but I am not aware that any botanist now living has seen it in that part of the state.

LACHNOCAULON BEYRICHIANUM Sporleder; Koernicke, Linnaea, **27**: 597. 1854

In rather dry pine-barrens near the eastern edge of Okefinokee Swamp in Charlton County, August 9 (*no. 1491*); also above high-water mark on the sandy shore of Ocean Pond, Lowndes County, September 4 (*no. 1607*). Previously known in Georgia only from the type-locality, "ad ripas paludum prope Ebenezer," where it was discovered by Beyrich about seventy years ago. Dr. Morong, in his remarks on this species,* erroneously places Ebenezer in Middle Georgia. The original Ebenezer, visited by Beyrich, was on the Savannah River in Effingham County, but is now extinct or nearly so. In later years there have been two or three other Ebenezers in Georgia, and it was probably one of these which misled Dr. Morong.

ERIOCAULON TEXENSE Koernicke, Linnaea, **27**: 594. 1854

Collected on July 2 in flat pine-barrens near Huntington, Sumter County, in a place which was quite dry at the time, but becomes a shallow pond in wet weather (*no. 1395*). Previously known only from Texas. (The reference to Florida under this species in Dr. Small's Flora is an error, probably typographical, Georgia having been intended.) This species is about intermediate in appearance between *E. compressum* and *E. decangulare*, and if it has been seen elsewhere in the East it has probably been mistaken for one of these other species.

TRADESCANTIA COMATA Small

In rich woods on Germain's Island in the Savannah River, Columbia County, 15 or 20 miles above the fall-line, June 7 (*no. 1296*). Altitude about 175 feet. Previously reported only from the mountains.

JUNCUS BRACHYCARPUS Engelm.

In river-bottoms near the same island, collected on the same day (*no. 1295*). Very few stations for this in the Southeastern States are known, probably no other in Georgia.

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* Bull. Torrey Club, **18**: 361, 362. D 1891.

MELANTHIUM DISPERSUM Small

Several specimens collected in a sandy bog in the pine-barrens east of Folkston, Charlton County, in full bloom on the morning of August 12 (*no. 1506*). Previously known only from a single imperfect specimen from Walton County, Florida, collected by A. H. Curtiss in 1885. *M. Virginicum*, its nearest relative, flowers a month or two earlier in Georgia.

UVULARIA FLORIDANA Chapm. (*Oakesiella Floridana* Small)

Not rare, in rich damp woods, Dublin, Laurens County, with full-grown fruit in June (*no. 1363*). Seen in October in similar situations near Cuthbert. The fruit, which has not hitherto been described, furnishes additional characters for distinguishing this species from its congeners. The capsule is always acuminate, tapering into a short beak, instead of being obtuse as in the two related species, *U. puberula* and *U. sessilifolia*. The bracted peduncle mentioned by Chapman, but overlooked by Small, seems to be also a perfectly constant character which is not shared by the other species.

CROOMIA PAUCIFLORA (Nutt.) Torr.

Collected in rich shady woods on the bank of the Chattahoochee River in Quitman County, October 16 (*no. 1757*), with flowers and fruit all gone. This is doubtless the only station in Georgia now known for this rare plant. Its resemblance to *Smilax ecirrhata*, which grows with it, is striking.

SALIX FLORIDANA Chapm.

I refer tentatively to this almost unknown species specimens collected in wet woods at the outer (eastern) base of the sand-hills of the Ocmulgee in Pulaski County below Hawkinsville, June 27 (*no. 1381*). My specimens were slender erect trees about ten feet tall and two inches in diameter, with tasteless bark roughish below and smooth above. The twigs were very brittle not only at the bases but throughout. No trace of fruit was found, but my material, as far as it goes, seems to be a perfect match for the type-specimen in the Torrey Herbarium, collected by Dr. Chapman in West Florida.

QUERCUS MYRTIFOLIA Willd.

Abundant on the driest sand-hills of the Satilla River in Pierce County near Waycross, where with other shrubby plants (and no herbs or trees) it forms almost impenetrable thickets six to ten feet high and of unknown extent (*no. 1466*). This locality is about 60 miles inland and 100 feet above sea-level. On August 19 I collected the same oak in a thicket of similar aspect, but somewhat different composition, in the interior of Cumberland Island (*no. 1540*). This species strikes me as being much more closely related to *Q. nigra* L. (*Q. aquatica* Walt.) than to *Q. Virginiana*, of which it was long considered a variety.

POLYGONUM ARIFOLIUM L.

In the swamp of the Satilla River in Camden County opposite Woodbine, within the influence of tide, but in fresh water, August 23 (*no. 1563*). My specimens are all sterile. Previous records of the occurrence of this species as far south as the coast of Georgia seem to be lacking. With it I found among other things *Juncus Canadensis* J. Gay, which was also a novelty in these parts.

MAGNOLIA MACROPHYLLA Michx.

This tree is common in rich woods along Samochechobee Creek all the way across Clay County (*no. 1793*), but I have never met with it elsewhere.

SARRACENIA FLAVA × MINOR Harper, Bull. Torrey Club, **30**: 332. Je 1903

Although described from a single specimen, this hybrid seems to be not particularly rare or evanescent. In July, 1902, I found (and photographed) several specimens within a few feet of each other in wet pine-barrens in Douglas, Coffee County (*no. 1437*). Here, as at the type-locality (about sixty miles distant) both parents were growing in the immediate vicinity. The hybrid has shown no tendency to flower yet.

SARRACENIA PURPUREA L.

After looking in vain for this species in Georgia for several years, I found a quantity of it in a sandy bog in Randolph County not far from Coleman (which is several miles outside of the pine-barrens) on October 28 (*no. 1783*). About the same time Mr. Hyde obtained a flowering specimen collected by the late Mrs. Sarah Thompson in Lee County, May 11, 1895.

Dr. Mohr in his "Plant Life of Alabama" says nothing about this species being rare in that state, but it is certainly rare in Georgia, and very few stations for it are known in the other southern states. All of the seven known species of *Sarracenia* have now been found in the coastal plain of Georgia. With the possible exception of Florida, no other state is known to contain them all.

CHRYSOBALANUS OBLONGIFOLIUS Michx.

Specimens collected in Coffee County on July 22 (*no. 1433*) showed a variation apparently hitherto unknown in this species and the genus and family to which it belongs. Many of the flowers had two or three carpels, and several specimens showed both or all three well on the way to maturity. The plants were perfectly normal in other respects, and there is no reason for supposing the extra number of carpels a freak. It is simply a variation which has been overlooked.

CUBELIUM CONCOLOR (Forst.) Raf.

Common on the bank of the Savannah River on Germain's Island, Columbia County (in the metamorphic region), June 7 (*no. 1297*). Also seen among limestone rocks in woods near Grier's Cave, Randolph County, October 23. Not previously reported from Georgia. My specimens differ from those which have been described, in being glabrous throughout, but seem to be otherwise identical.

ERYNGIUM LUDOVICIANUM Morong (*E. integrifolium Ludovicianum* C. & R.)

Observations on this species during the season convince me that it is specifically distinct from *E. integrifolium* Walt. (*E. virga-*

tum Lam.). While the two species are similar in habitat, their ranges are different. Near the southern border of the state, in the counties of Lowndes, Brooks and Thomas, *E. integrifolium* alone occurs, while fifty miles farther north, in the vicinity of Tifton, I have seen only *E. Ludovicianum.* But around Moultrie, an intermediate point, both species occur, often together, without showing any tendency to intergrade.

E. integrifolium has much the wider range, even in Georgia, where it is found in the metamorphic region as well as in the coastal plain. It is represented by *no. 1612*, from Valdosta, September 5, and *E. Ludovicianum* by *no. 1664*, from Colquitt County, September 24.

PANAX QUINQUEFOLIUM L.

In rich shady woods northwest of Cuthbert, Randolph County; also on the high bluff along Samochechobee Creek in Clay County. Rarely found so far south, these localities being below latitude 32°. I have heard several rumors of the occurrence of this much-sought plant elsewhere in the coastal plain, but most of these on being investigated prove to be based on *Tetragonotheca helianthoides* L., a totally dissimilar plant which in some unaccountable way has also received the name of "ginseng,"* and moreover is said to possess valuable medicinal properties, being "good for rheumatism."

CHIMAPHILA MACULATA (L.) Pursh

A few specimens seen on September 29 in rich woods near Little River southwest of Tifton, Berrien County. This species does not seem to have been found so far south before.

ANANTHERIX CONNIVENS (Baldw.) Feay; Wood, Class Book, 594. 1861

The authorship of this combination is usually credited to Gray (Proc. Am. Acad. **12**: 66. 1876), but it was published in Wood's Class Book several years earlier. I collected this species in full bloom in wet pine-barrens in Coffee County near Douglas, July 18 (*no. 1426*), and observed it in similiar situations in several other

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* This fact was noted by Messrs. Pollard and Maxon in 1900. See Plant World, 3: 142. S 1900.

Southeast Georgia counties. It seems to be always scarce, rarely more than three or four specimens being visible at once.

DICERANDRA ODORATISSIMA Harper, Bull. Torrey Club, **28**: 479. 1901

Collected on the sand-hills of Little River southwest of Tifton, Berrien County, September 30 (*no. 1695*). At this station, which is probably near the western limit of the species (sand-hills being rare farther west), the plants are much less abundant and vigorous than at the type-locality, forty miles farther east.

GERARDIA GEORGIANA C. L. Boynton, Biltmore Bot. Stud. **1**: 148. 1902

Collected in rather dry pine-barrens around a small pond in Thomas County south of Thomasville on the morning of September 19 (*no. 1637*). Intimately associated with *G. paupercula* (Gray) Britton (*no. 1638*), which it much resembles, though this is not necessarily its nearest relative. Previously known only from the type-locality, near Cordele. One character overlooked by the author is that the corolla of *G. Georgiana* is spotless. I find that the markings of the corollas in *Gerardia*, which can be studied to advantage only in living specimens, often afford valuable diagnostic characters.

GERARDIA FILICAULIS (Benth.) Chapm.

Seen only in rather dry grassy pine-barrens near Tyty, Worth County, on the morning of September 30 (*no. 1698*). Fairly abundant but very inconspicuous. Not previously reported north of Florida.

LOBELIA FLACCIDIFOLIA Small

Collected in the swamp of Cedar Creek near Wrightsville, Johnson County, in flower June 16 (*no. 1341*), also in the swamp of Ochlocknee Creek near Moultrie, Colquitt County, September 25 (*no. 1676*). Flowers earlier than most species of *Lobelia.*

EUPATORIUM INCARNATUM Walt.

Seen only in the rocky woods near Grier's Cave, Randolph County, in flower October 23 (*no. 1771*). Probably not known elsewhere in Georgia. Dr. Mohr reports but one station for it in Alabama.

CHRYSOPSIS PINIFOLIA Ell.

On the fall-line sand-hills near Butler, Taylor County, November 6 (*no. 1802*). The only earlier specimen I have seen was collected by Elliott himself in the same region. This species becomes stoloniferous late in the season, a fact which has not been noted before.

SOLIDAGO AMPLEXICAULIS T. & G. Fl. N. A. **2**: 218. 1842

Not rare in rich shady woods in Randolph County northwest of Cuthbert, in full bloom on October 21 (*no. 1764*). Not previously reported from Georgia. This species was named in a rather unusual way. The authors when describing it assumed it to be the same as *S. amplexicaulis* Martens,* of which they had seen the name but not the description. Soon afterward † they found that Martens' *S. amplexicaulis* was a synonym of *S. Riddellii* Frank. According to the views held at that time, this necessitated no change in the name of Torrey and Gray's plant, but on the principle of "once a synonym always a synonym," it would have to be changed. This is a case which seems to have escaped the attention of the nomenclature reformers.

BALDWINIA ATROPURPUREA Harper, Bull. Torrey Club, **28**: 483. 1901

At the time I described this species I had some doubts as to its validity, but I have none now. In 1902 I collected it near Moultrie on September 20 (*no. 1644*), and in the next two weeks saw it at many other places in the counties of Colquitt, Worth, Berrien, Irwin and Dooly, always in moist slightly sloping pine-barrens. It grows in wetter places than does *B. uniflora* (but the two species are often found near together), and flowers several weeks later. I find also that its involucral bracts are smaller and more numerous than those of its congener. Also that the stems are usually purplish at the base, and commonly produce more branches (and consequently more heads) than in *B. uniflora*. There is not the slightest possibility of confusing the two species, and it is remarkable that *B. atropurpurea* was overlooked so long.

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* Bull. Acad. Brux. **8**: 66. 1841.

† Fl. N. A. **2**: 504. 1843.

MARSHALLIA RAMOSA Beadle & Boynton, Biltmore Bot. Stud. **1**: 8. *pl. 2.* 1901

In dry pine-barrens and at bases of imperfectly developed sand-hills in Johnson county near Wrightsville. In flower June 16 (*no. 1342*). This seems to be the second collection made of this species. Its corollas are decidedly paler than those of the common species, *M. graminifolia*, being nearly white.

MESADENIA SULCATA (Fernald) Small (*Cacalia sulcata* Fernald)

Collected in wet woods about a mile east of Killen, Clay County, October 29 (*no. 1792*), also seen in similar places in Randolph County south of Cuthbert. The affinity of this species with *Cacalia ovata* Ell. (which may not be the same as *C. ovata* Walt.), to which Mr. Fernald compared it, is rather remote. It is much more closely related to *M. tuberosa* (Nutt.) Britton and *M. Floridana* (Gray) Greene. These three species, *tuberosa*, *sulcata* and *Floridana*, differing from each other principally in range, habitat and shape of leaves, form a small group characterized by grooved or sharply angled stems, plantain-like leaves green on both sides and tapering at the base, and especially by the winged keels of the involucral bracts. This latter character was overlooked by the authors of the two latter species and is very rarely mentioned in descriptions, being inconspicuous in dried specimens. The wings are usually 1–2 mm. broad.

A specimen collected by A. H. Curtiss on "Borders of swamps, Walton County, Florida," in September, probably many years ago (*no. 1560*, distributed as *Cacalia Floridana*), is *Mesadenia sulcata*. In the Biltmore Herbarium there are specimens of it collected at different points in the same county, August 1, 1899, and September 26, 1900.

COLLEGE POINT, N. Y.

The Publications of the Department of Botany, Columbia University, consist of Memoirs in quarto and Contributions in octavo.

The Memoirs already published are:—

Vol. I. **Small.** A Monograph of the North American Species of the Genus *Polygonum.* Pp. 178. 84 plates. 1895. Price, six dollars.

Vol. II. **Rydberg.** A Monograph of the North American Potentilleae. Pp. 224. 112 plates. 1898. Price, six dollars.

The Contributions have now reached the ninth volume.

Vol. I. Nos. 1–25 (1886–1892). Out of print, except Nos. 6, 7, 11, 13, 17, 20, 21, 22, 24. These can be supplied at twenty five cents each, except No. 6, which is one dollar.

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28 1906

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THE EFFECT OF CHEMICAL IRRITAT
RESPIRATION OF FUNG

By ADA WATTERSON

NEW YORK
1904

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The effect of chemical irritation on the respiration of fungi

ADA WATTERSON

The effect of chemical irritation upon the growth of fungi has been the subject of considerable study for a number of years past. The results obtained by Raulin,* Richards,† Ono,‡ Hattori,§ and others have gone to prove that certain metallic salts, in small quantities, stimulate the metabolic activity of various fungi and thereby induce a more rapid growth than is normal. This action is interpreted by Richards ‖ as being a means by which the plant is enabled to dispose more economically of the sugar or other source of the carbohydrates required in growth.

The fungi used by Richards in his experiments were *Sterigmatocystis* (*Aspergillus*) *niger*, *Penicillium glaucum*, and *Botrytis*, and the substances which served as irritants were zinc, iron, cobalt and nickel sulphates, NaFl, LiCl, Na_2SiO_3, cocaine, morphine and amygdalin. Ono made use of the same irritants with the addition of $HgCl_2$. Hattori experimented with $CuSO_4$; Yasuda¶ with certain alkaloids; Hueppe** found the activities of bacteria stimulated by certain poisons. Schultz †† likewise observed an acceleration of fermentation in yeast following the addition of small quantities of poisonous substances, but whether this was due to a more rapid growth and division, or to greater activity of the individual cells, has not been determined.

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* Raulin, J. Études chimiques sur la végétation ; deuxiéme partie. Ann. Sci. Nat. Bot. V. 11 : 190–299. 1869.

† Richards, H. M. Die Beeinflussung des Wachsthums einiger Pilze durch chemische Reize. Jahrb. Wiss. Bot. 30 : 665–688. 1897.

‡ Ono, N. Ueber die Wachsthumsbeschleunigung einiger Algen und Pilze durch chemische Reize. Jour. Coll. Sci. Imp. Univ. Tokyo, 13 : 141–186. 1900.

§ Hattori, H. Studien über die Einwirkung des Kupfersulfats auf einige Pflanzen. Jour. Coll. Sci. Imp. Univ. Tokyo, 15 : 371–394. 1901.

‖ Richards, H. M. The effect of chemical irritation on the economic coefficient of sugar. Bull. Torrey Club, 26 : 463–479. 1899.

¶ Yasuda, A. On the effect of alkaloids upon some moulds. Bot. Mag. Tokyo, 15 : 79–83. 1901.

** Hueppe, F. Naturwissenschaftliche Einführung in die Bakteriologie, 55. Wiesbaden, 1896. (Not seen.)

†† Schultz, H. Pflüger's Archiv, 42 : —. 1888. (Reference in Bot. Zeitung, 46 : 610. 1888.)

Experiments were likewise performed by Ono on algae with like results except that the optimum concentration of the stimulants was much smaller. Similar work has been done on the phanerogams by Copeland and Kahlenberg * using pure metals as stimulants, by Townsend † with ether and HCl, and by Kahlenberg and True.‡ Chapin § also found an increase in the growth of certain seedlings due to the presence in the atmosphere of small amounts of CO_2, larger quantities of which acted as a poison.

In all of these cases the amount of stimulation is indicated by the increase in the plant body, as shown by dry weight in the case of the fungi and algae, and by the increased surface of the organs of phanerogams. It is well known, however, || that only a part of the nutrient material absorbed by the plant is used to build up its living substance; a part is continually being oxidized to provide the necessary energy for carrying on life-processes. Fully to determine, therefore, the relation between the plant and its food-supply, one would have to take into account both the amount of the latter which is used as constructive material, measured by the increased weight or size of the plant, and that which undergoes katabolic changes during which CO_2 and other waste products are liberated.

Richards' experiments were concerned with the first factor, that is, the amount of dry substance produced and its relation to the amount of sugar used, or the economic coefficient. Ono confirmed his results, and in addition he determined the relative quantities of oxalic acid produced by fungi under normal conditions and under stimulation, finding a decrease in the latter case with all substances tried except $NiSO_4$. To account for this Ono suggests

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* Copeland, E. B., and Kahlenberg, L. The influence of the presence of pure metals upon plants. Trans. Wisc. Acad. 12 : 454–474. 1899.

† Townsend, C. O. The correlation of growth under the influence of injuries. Ann. Bot. 11 : 509–532. 1897. — The effect of hydrocyanic acid gas upon grains and other seeds. Bot. Gaz. 31 : 241–264. 1901.

‡ Kahlenberg, L., and True, R. H. On the toxic action of dissolved salts and their electrolytic dissociation. Bot. Gaz. 22 : 81–124. 1896.

§ Chapin, P. Einfluss der Kohlensäure auf das Wachsthum. Flora, 91 : 348–379. 1902.

|| Pfeffer, W. Physiology of plants, ed. 2, 1 : 287, 523. 1900.

that the carbohydrate which during normal growth is decomposed, in the processes of metabolism, to form oxalic acid, is not so transformed during the accelerated growth resulting from stimulation, but is immediately changed into constructive material for the plant body. Of this, the decrease in the economic coefficient (*i. e.*, ratio of dry weight to sugar used) of the stimulated cultures seems an indication. Oxalic acid is not, however, the only waste product of metabolism. Since, according to Pfeffer,* "a decreased formation of oxalic or other organic acids is accompanied by an increase in the ratio of CO_2 exhaled to the oxygen absorbed," the amount of CO_2 given off under the varying conditions must also be reckoned with; it must be determined, that is, whether all the additional carbohydrate normally used to produce oxalic acid is now transformed into formative substance, or whether part of it may be wholly oxidized to produce larger quantities of CO_2. This ratio of the dry substance produced to the amount of CO_2 exhaled, or the respiratory quotient, was found by Kunstmann † to vary with changing conditions, decreasing with a rise of temperature or with higher concentrations of the nutrient solution. The effect of chemical stimulation was not included among the conditions.

The effect of such stimulation upon respiration alone without regard to the possible acceleration of growth ensuing was studied by Jacobi,† who obtained an increase in amount of CO_2 produced by certain phanerogams, due to the influence of KCl, NaCl, KNO_3, iodine, chinin, antipyrin, oxalic acid and various organic substances. Copeland ‡ obtained similar results; and likewise Kosinski § in the case of fungi. Morkowin || found a decided

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* Pfeffer, W. Physiology of plants, ed. 2, 1 : 527. 1900.

† Kunstmann, H. Ueber das Verhältnis zwischen Pilzernte und verbrauchter Nahrung. Leipzig. 1895. [Inaug. Diss.]

‡ Jacobi, B. Ueber den Einfluss verschiedener Substanzen auf die Athmung und Assimilation submerser Pflanzen. Flora, 86 : 289–327. 1899.

§ Copeland, Bot. Gaz. 35 : 81–98, 160–183. 1903.

|| Kosinski, I. Die Athmung bei Hungerzuständen und unter Einwirkung von mechanischen und chemischen Reizmittteln bei *Aspergillus niger*. Jahrb. Wiss. Bot. 37 : 137–204. 1901.

¶ Morkowin, N. Recherches sur l'influence des anesthésiques sur la respiration des plantes. Revue Gén. de Bot. 11 : 289–303, 341–352. 1899. — Ueber den Einfluss der Reizwirkunzen auf die intramoleculare Athmung der Pflanzen. Ber. Deut. Bot. Ges. 21 : 72. 1903.

increase in the intensity of respiration, both normal and intramolecular, of etiolated leaves and shoots under the influence of ether, alcohol and various alkaloids. Pfeffer states * that according to Elfving and Lauren adult parts of higher plants, where stimulation is unaccompanied by growth, react in the same manner to a short treatment with ether and chloroform ; he notes however that Detmer and also Bonnier and Mangin found no such reaction.

Summarizing then, the results quoted, we find that small quantities of certain poisonous substances act as stimulants, increasing the growth of certain plants; they also increase respiration, but what relation the latter increase bears to the former is not determined. Since, however, in the case of fungi, it has been found that stimulation raises the economic coefficient of the sugar, *i. e.*, allows the plant to make use of the sugar to form a greater amount of dry substance in a given time, the question of the amount of CO_2 which is produced at the same time becomes one of interest.

This problem was suggested to me by Dr. H. M. Richards, to whom I wish to express my gratitude for his interest and valuable assistanee. The work was done in the botanical laboratory of Barnard College during the winters of 1901–1902 and 1902–1903.

Two kinds of apparatus have been employed in carrying on this work, one that of Godlewski described by Kunstmann † the other a modification of the Pfeffer-Pettenkofer apparatus. In all the experiments, however, the fungi used were *Sterigmatocystis nigra* and *Penicillium glaucum*. The formula for the nutrient solution was that given by Richards : ‡

KH_2PO_4	0.05g.
$MgSO_4$	0.25g.
NH_4NO_3	1.00g.
$FeSO_4$	trace.
Sugar	5.00g.
Water	100 cm.

Only the purest chemicals and sugar obtainable were used, and the water was twice distilled. The dishes and flasks in which the cultures were grown were rinsed with dilute HCl, carefully washed with double-distilled water and dried in a dry sterilizer. The spores were sown by rubbing small pieces of glass rod, exactly equal in size, upon the dry stock supply, and then transferring them to the dishes by means of glass tipped forceps. It was found convenient to keep a supply of the concentrated nutrient solution on hand, containing all the ingredients except sugar. The necessary amount was diluted and the sugar added when the series was set up.

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* Pfeffer, W. Physiology of plants, Ed. 2, 1 : 564. 1900.

† Kunstmann, *l. c.* 10. 1895.

‡ Richards. Jahrb. Wiss. Bot. 30 : 667. 1897.

At first the Godlewski apparatus used by Kunstmann was employed. This consisted, in brief, of a bell-jar enclosing two crystallizing dishes; the smaller of these held the fungus growing on 75 c.c. of the nutrient solution, and rested upon a glass strip placed across the larger dish which contained 150 c.c. of a 10 per cent. solution of KOH. The mouth of the jar was closed with a rubber cork provided with two holes through one of which passed a thermometer, and through the other a glass tube leading to a mercury valve, with which, in turn, was connected a KOH tube in such a way that air could pass into the jar, but could not escape from it. The bell-jar was sealed to a ground glass plate by means of vaseline and the joining was then painted with two coats of shellac to make it water tight. Three jars were used, one to serve as a control, and two for the experiment; the results given are, unless otherwise stated, the average of the two grown at the same time and under the same conditions. The greatest difficulty was experienced in keeping the cultures at an even temperature, approximately near the optimum for *Sterigmatocystis*, which is 30–34° C. The plan finally followed was to place all three jars in a zinc trough partly filled with water, the temperature of which would change more slowly than that of the air, and then to enclose the whole in a wooden box placed near a steam radiator. Under these conditions the temperature was raised to the neighborhood of 30° C., and varied not more than three or four degrees during any one experiment.

At the close of the experiment the fungus was killed with formalin as soon as the jar was opened, washed with distilled water, collected in weighed filter papers, dried in an oven at a temperature of 70° C., and after cooling in a dessicator was carefully weighed. The KOH was diluted to 250 c.c.; the CO_2 was precipitated out of it by an equal quantity of barium hydrate, and the alkalinity of the remaining KOH was determined by titrating in the usual way with HCl of such strength that 1 c.c. of the acid = 1 mg. of CO_2. The result was then subtracted from that obtained by treating a certain amount of the stock KOH in the same way, and thus the amount of CO_2 given off by the fungus was obtained. The results are given in milligrams both for the weight of the fungus and the amount of CO_2 given off.

At the same time a series of experiments was carried on with a form of the Pfeffer-Pettenkofer respiration apparatus. The particular object in using this was to determine the rate of respiration during short intervals of time. Certain practical difficulties made this impossible, however, at that time, and the attempt was abandoned. Later, the same apparatus was started again in a slightly different way; *i. e.*, a strong solution of KOH was used and the same experiment was continued for a week at a time. It was set up in the dark room, which, being small and kept carefully closed, could be maintained at a comparatively even temperature in the neighborhood of 24° C.

The air in entering the apparatus passed through three U-tubes filled with pumice stone wet with a strong solution of KOH which was frequently renewed. A $Ba(OH)_2$ test-bottle was placed in the course to prove that no CO_2 passed over to the cultures, and the air was then distributed to these, four in number, by means of a T-tube and two Y-tubes. The cultures were grown in Erbenmeyer flasks of about 250 c.c. capacity, in which only 75 c.c. of the nutrient solution was used. This brought the film of mycelium at the level of the widest diameter of the flask and the flasks were all as nearly as possible of the same diameter. Between the culture flasks and the Pettenkofer tubes were interposed large test-tubes to prevent any possible backward flow of the KOH into the culture flasks; 150 c.c. of a 10 per cent. solution of KOH was introduced into the absorption tubes by means of a large pipette; the stock solution was kept in a tightly stoppered bottle sealed with vaseline. At the exit end of the tubes were placed screw pinch-cocks to regulate the amount of air drawn through the apparatus, which was measured by the size and rate of flow of the bubbles of air in the tubes. Any slight difference in the rate of flow would be of no importance when the length of time during which the experiment ran — six to nine days — is taken into consideration. Between the tubes and the aspirator were inserted $Ba(OH)_2$ test-bottles. The aspirator was a simple one fastened to the water faucet.

At the close of the experiment the aspirator was shut off, the stop-cocks closed, the cultures immediately killed with formalin, and the contents of the tubes quickly emptied into bottles which were tightly corked. The amount of CO_2 absorbed was obtained by titration as before.

The metallic salts used as irritants in these experiments were $ZnSO_4$, $FeSO_4$ and LiCl. In each case such a concentration was used as had been found by Richards to be most favorable for an increased growth of the fungus. A 1 per cent. stock solution of anhydrous $ZnSO_4$ was made carefully; of this, .3 c.c. was used for 75 c.c. of the nutrient solution, giving thus a .004 per cent. solution or, expressed in terms of a normal (gram equivalent) solution,* .00049; of the $FeSO_4$, a .082 per cent. solution was used, or .01078 normal; and of LiCl, a .162 per cent. solution or .03822 normal.

In the following tables the results of the experiments are presented. In the first are given five series carried on with the Kunstmann apparatus, for three or four days at a temperature of 28°–31° C. The irritant was $ZnSO_4$. In the first column are given the dry weights of the cultures, both normal and irritated; in the second the amount of CO_2 given off by each, expressed in millegrams; and in the third the ratio of the weight to the CO_2. On examination of these figures it is evident that the addition of the zinc has caused an increase in the growth of the fungus and there has been likewise an increase in the amount of CO_2 respired. The amount of CO_2 respired is sometimes less than the corresponding weight of the culture, sometimes more, but when one compares the ratios of the two cultures in any one series, one finds very little difference between them; that is, the increase in respiration has been correspondingly great in both, with perhaps a slight advantage on the side of the irritated fungus. There is one exception to this, the fourth series, where the difference is unaccountably great, owing to an unusually large evolution of CO_2 from the stimulated culture. The increase in the amount of CO_2 given off is therefore but little greater than might naturally be expected from the increased respiratory surface due to the greater growth of the fungus.

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* Livingston, B. E. The rôle of diffusion and osmotic pressure in plants, 22. 1903.

The second table shows the results of five experiments performed with the Pettenkofer apparatus; the cultures, being grown at a lower temperature, 20–24° C., were allowed to run for a longer time: five, six, or seven days. In these, the figures for the irritated fungus represent the average of three cultures, grown under precisely similar conditions. Here too the ratios are very near one another. It is noticeable however that the difference, such as it is, is reversed in the second table, in all but one case, and the respiration of the normal grown in the Pettenkofer apparatus is therefore apparently a little greater, relatively, than that of the irritated fungus. The cause of this reversal of the ratios obtained by the two methods I have not been able to determine, but the difference is too slight to be of any importance. In Tables IX and X are given the same figures as in I and II, but the averages are found for the weights, CO_2, and ratios of each set of series; that is, for the series obtained by the Kunstmann method (Table IX), the average ratio of weight to CO_2 for the normal is .98, for the stimulated culture is 1.18; for those in the Pettenkofer apparatus (Table X) the average is 1.16 for the control as against .94 for the stimulated fungus.

Bearing these figures in mind, let us refer again to Ono's experiments in determining the amount of oxalic acid produced by fungi during growth under stimulation. With all the irritants used, with the exception of $NiSO_4$, he found a more or less marked decrease in the production of oxalic acid, a decrease shown (to quote some of his figures) * by the difference between 2.58 acid for every gram of dry weight of the normal, and 0.428 for the culture to which has been added .003 per cent $ZnSO_4$. The duration of this experiment was twenty-seven days and the temperature 16–20° C. Ono suggests three possible explanations for this de-

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* Ono, *l. c.* 174. 1900.

crease:* (1) Although oxalic acid is a normal product of metabolism of the fungus, it is to be regarded nevertheless as a product of incomplete oxidation, and if the metabolic activity were increased, more CO_2 might be produced and therefore less oxalic acid. (2) The same result would occur in case the acid should disappear through a further "working-over" on the part of the fungus. Thereby it could be taken up again as building material or be decomposed without being useful to the fungus. Yet, as shown by Wehmer,† oxalic acid is poor food stuff for *Aspergillus*, and in the presence of a plentiful supply of sugar would probably remain intact. (3) Those materials (carbohydrates, etc.) which in normal growth are, by metabolism, transformed in part into oxalic acid, in consequence of increase in growth due to the stimulation are not separated out in that form, but are changed directly into the fungus body, in short, are applied as formative material.

Of these three possibilities, Ono concludes from his experiments that the third is the true explanation, since in every case the economic coefficient was much greater in the control than in the stimulated fungus. "Dieses Verhältnis deutet also an, das die Pilze bei Anvesenheit von Zinksulfat veranlasst wurden, mit einem verhältnismässig kleinen Verbrauch von Zucker eine bedeutend grössere körpersubstanz aufbauen zu können." ‡ This was also the conclusion reached previously by Richards. §

Further support is now given to this explanation by the results presented here, since Ono's first suggestion is thereby eliminated; that is, the present figures show that an amount of CO_2 is produced by the stimulated fungus which varies a little, being either more or less relatively to the weight of the fungus than that produced by the normal, but still remains comparatively close to the latter. The increase in metabolic activity has, therefore, not increased (relatively) the production of CO_2 although the formation of oxalic acid under similar conditions was materially checked, and the carbohydrates formerly used in the manufacture of the latter must consequently be devoted to the building up of new substance in the plant.

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* *Idem*, 157. 1900.

† Wehmer, Bot. Zeitung, 49: 553. 1891.

‡ Ono, *l. c.* 160. 1900.

§ Richards, H. M. The effect of chemical irritation on the economic coefficient of sugar. Bull. Torrey Club. 26: 463–479. 1899.

In Table III two series are shown, in which glycerine was used instead of sugar as the source of the carbohydrate. All of the figures here are rather low, owing to the slower growth of *Sterigmatocystis* in such a nutrient medium; the ratios, however, bear much the same relation to one another as in the preceding series, .61 and .69 (normal) to .77 and .68 (stimulated), respectively.

In the experiments recorded in Table IV, .082 per cent. (.01078 normal) $FeSO_4$ was used as the stimulant, since this concentration is near that which caused the greatest increase in growth in Richards' experiments. A .162 per cent. (.0381 normal) solution of LiCl was also tried (Tables V and VI), and although the increase in growth was not as great as might have been expected from Richards' results, yet the evolution of CO_2 bears much the same relation to it as in the preceding cases.

A few experiments were likewise made with *Penicillium glaucum*. Though *Penicillium* grows well at a lower temperature than does *Sterigmatocystis*, yet it grows slowly, and the total weight of the normal is seldom as great as is that of *Sterigmatocystis* in the majority of cases. The evolution of CO_2 is nevertheless very active, and the number of milligrams of CO_2 given off exceeds that of the dry weight of the fungus. Several of these cultures were raised on the usual nutrient medium (Table VII), and one (Table VIII) on a solution in which .5 gr. asparagin replaced the NH_4NO_3 as the source of nitrogen. The weight of the irritated fungus in the latter case was much greater than that of the normal, but the evolution of CO_2 kept pace with it to such an extent that the ratio is 1.22 as compared with 1.26 in the normal.

In reviewing, then, the results recorded here, it is evident that the addition of small quantities of $ZnSO_4$, $FeSO_4$ and LiCl has increased the rate of growth of *Sterigmatocystis* and *Penicillium* so that a larger amount of dry substance is produced within a given time than in normal cultures; that at the same time there has been an increase in the production of CO_2, an increase not too great, however, to be accounted for by the enlarged area of the plant. The ratio of dry weight to CO_2 of the irritated fungus is therefore approximately equal to that of the normal. Taking into account previous results which show that the effect of the addition of such poisons is to enable the plant to make more economical use of the carbohydrates supplied to it, we can interpret this action as a stimulus which causes the fungus to transform more of the food material into its own substance, and less into waste products such as oxalic acid, while at the same time the respiration remains relatively unchanged.

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TABLE I.

Kunstmann apparatus.

Sterigmatocystis nigra. 5 per cent. sugar solution.

A = Normal. B = average of two cultures to which .004 per cent.* or .00049 normal (gram equivalent) $ZnSO_4$ has been added. Temperature 28–30°C.

		Weight of Fungus.	CO_2	Ratio.	Time.
I.	A	335.2	155	.46	3 days.
	B	597.6	392.5	.67	
II.	A	398.5	455	1.13	3 "
	B	607.1	755	1.27	
III.	A	479.7	705	1.46	4 "
	B	805.1	1185	1.47	
IV.	A	480.8	415	.86	4 "
	B	783.7	1230	1.56	
V.	A	533.6	465	.87	4 "
	B	875.6	780	.89	

TABLE II.

Pettenkofer apparatus.

Same as in Table I, except that B = average of *three* cultures to which .004 per cent.,* (.00049 normal) $ZnSO_4$ has been added. Temperature 20–24° C.

		Weight of Fungus.	CO_2	Ratio.	Time.
VI.	A	600	420	.70	7 days
	B	1138.1	987	.86	
VII.	A	673.6	768	1.14	7 "
	B	888.0	888	1.00	
VIII.	A	885.5	1173	1.32	7 "
	B	1086.6	1143	1.05	
IX.	A	1056.0	978	.92	6 "
	B	1237.2	1036	.83	
X.	A	715	936	1.30	5 "
	B	1327	1263	.95	

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* Calculated as anhydrous salt.

Table III.

Pettenkofer apparatus.

Nutrient solution a 5 per cent. glycerine instead of sugar; otherwise as in Table II. B = .004 per cent.* (.00049 normal) $ZnSO_4$.

		Weight.	CO_2	Ratio.	Time.	Temp.
XI.	A	489	300	.61	7 days.	23–25°
	B	1194.7	920	.77		
XII.	A	358.5	249	.69	7 "	20–24°
	B	724.3	498	.68		

Table IV.

Pettenkofer apparatus.

Same as in Table II, but B = .082 per cent.* (.01078 normal) $FeSO_4$.

		Weight.	CO_2	Ratio.	Time.	Temp.
XIII.	A	1142.5	867	.75	6 days.	26–29°
	B	1691	1513	.89		
XIV.	A	687	180	.26	6 "	
	B	1449.4	830	.57		

Table V.

Kunstmann apparatus.

Same as in Table I, but B = .162 per cent.* (.0381 normal) LiCl.

B here was not an average of two, but a single culture. Temperature 19–28° C.

		Weight of Fungus.	CO_2	Ratio.	Time.
XV.	A	615.5	514	.83	11 days
	B	775.5	814	1.04	

Table VI.

Pettenkofer apparatus.

Same as in Table II, but B = .162 per cent.* (.0381 normal) LiCl.

		Wght. Fungus.	CO_2	Ratio.	Time	Temp.
XVI.	A	1434	1110	.78	7 days	25°C.
	B	1501.1	1311	.87		
XVII.	A	679	645	.94	8 "	22°–27°C.
	B	723.7	747	1.03		

* Calculated as anhydrous salt.

TABLE VII.

Pettenkofer apparatus.

Penicillium glaucum. Otherwise as in Table II. B = .004 per cent.* (.00049 normal) $ZnSO_4$.

		Wght. Fungus.	CO_2	Ratio.	Time.	Temp.
XVIII.	A	489.50	705	1.43	7 days	18–22°C.
	B	525.75	739.5	1.40		
XIX.	A	438.5	729	1.66	9 "	19–22°C.
	B	539.33	991	1.66		

TABLE VIII.

Pettenkofer apparatus.

Penicillium glaucum.

Same as in Table VII., but .5 grams asparagin used in place of NH_4NO_3. B = .004 per cent.* (.00049 normal) $ZnSO_4$.

		Weight.	CO_2	Ratio.	Time.	Temp.
XX.	A	354.5	450	1.26	9 days.	17.5–20°
	B	932.16	1145	1.22		

TABLE IX.

Kunstmann apparatus. Average of five series shown in Table I. .004 per cent.* (.00049 normal) $ZnSO_4$.

	Normal.			Average of 2.		
	Weight.	CO_2	Ratio.	Weight.	CO_2	Ratio.
I.	335.2	155	.46	597.6	392.5	.67
II.	398.5	455	1.13	607.1	755	1.27
III.	479.7	705	1.46	805.1	1185	1.47
IV.	480.8	415	.86	783.7	1230	1.56
V.	533.6	465	.87	875.6	780	.89
Average.	445.56	439	.98	733.8	868.5	1.18

TABLE X.

Pettenkofer apparatus. Average of five series shown in Table II .004 per cent.* (.00049 normal) $ZnSO_4$.

	Normal.			Average of 3.		
	Weight.	CO_2	Ratio.	Weight.	CO_2	Ratio.
VI.	600	420	.70	1138.1	987	.86
VII.	673.6	768	1.14	888.0	888	1.00
VIII.	885.5	1173	1.32	1086.6	1143	1.05
IX.	1056.0	978	.92	1237.2	1036	.83
X.	715	936	1.30	1327.0	1263	.95
Average.	759.4	885.37	1.16	1207.23	1138.2	.94

*Calculated as anhydrous salt.

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NEW YORK CITY.

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CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 209.

STUDIES IN SISYRINCHIUM—X

THE SPECIES OF CALIFORNIA

BY EUGENE P. BICKNELL

NEW YORK
1904

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 31: 379-391.]

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 31 : 379-391. July, 1904.]

Studies in Sisyrinchium — X. The species of California

EUGENE P. BICKNELL

The blue-eyed grasses of California, as shown by the collections which have passed under review in a study of the group, are common in many parts of the state and in nearly all parts are represented by one or more species, forming a noteworthy if not everywhere conspicuous element in the flora.

The widely diversified topographical features and sharply contrasted climatic conditions embraced within the great area of the state might well lead us to expect some striking reflection in so responsive a genus as *Sisyrinchium* occurring throughout, more especially since so many other sections of the United States have been found to possess a more or less characteristic group of species, and yet it has long been commonly supposed that scarcely more than a single species belonged to the California flora. In fact since Dr. Watson, in 1877, separated the most conspicuous California species from its eastern relatives under the name of *Sisyrinchium bellum* this name has been in common use for almost all specimens collected within the boundaries of the state.*

Within these boundaries, however, is an interesting group of species few of which appear to extend far beyond them. How many species make up this group cannot as yet be determined. Six or seven come out clearly enough from the mass of specimens which have been available for study, and others might be proposed on evidence perhaps sufficient yet not altogether convincing. For the present seven species are recognized. Of these *Sisyrinchium bellum*, the most conspicuous, appears also to be the most abundant. It proves, however, to be not at all of general distribution throughout the state, being restricted, or very nearly so, to the coastwise counties, through which it ranges from San Diego, and doubtless Lower California, northward into Mendocino County, from beyond which no specimens have been forthcoming. This species bears the distinction of having flowers of larger maximum size than any other species of the United States, although surpassed in both the size and beauty of its flowers by *Sisyrinchium Macounii* of Vancouver Island.

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* The yellow-flowered species formerly included in *Sisyrinchium* are here excluded from consideration, having already been separately treated under the revised genus *Hydastylus*. (Studies in *Sisyrinchium* — VIII. Bull. Torrey Club, 28 : 570-592. 1901.)

The even more distinct genus *Olsynium* of Rafinesque takes over another plant long accepted as a *Sisyrinchium*, the *Sisyrinchium grandiflorum* Douglas, as already pointed out. (Studies in *Sisyrinchium* — VII. Bull. Torrey Club, 27 : 237. 1900.)

In the Sierra Nevada region, northward from about the middle of the state, and beyond into Oregon, *Sisyrinchium bellum* is replaced by a slighter and smaller-flowered plant, *Sisyrinchium Greenei* sp. nov., which appears to be generally representative of that region, while in the valleys and mountains of the southern part of the state away from the coast another species, *Sisyrinchium Eastwoodiae* sp. nov., appears to be equally representative. A further, somewhat obscure species from the southwestern ranges nearer the coast is admitted as *Sisyrinchium hesperium* sp. nov. Four species appear from the extreme eastern parts of the state, one very distinct and apparently local species, *Sisyrinchium funereum* sp. nov., in the southeast, and three, *Sisyrinchium halophilum* Greene, *Sisyrinchium leptocaulon* Bicknell and *Sisyrinchium oreophilum* sp. nov., all simple-stemmed plants, mostly in the Sierra Nevada region.

SISYRINCHIUM HALOPHILUM Greene, Pitt. **4**: 34. 1899.

Inyo County, *Bishop;* Owen's Valley, alt. 5,000 ft., May 15, 1897, *M. E. Jones*, Herb. Missouri Bot. Gard. (not U. S. Nat. Herb., as cited in error Bull. Torrey Club, **26**: 451. 1899); Sierra Nevada Mts., 1875, *J. G. Lemmon*, U. S. Nat. Herb.

These specimens are stouter and broader-leaved, with thicker roots and perhaps larger flowers than the type, but are without perfect flowers and fruit and can be referred to no other species at present described.

The range of *S. halophilum* may be extended to Idaho, Wyoming and Colorado. From these states come a series of small, slender plants which, while contrasting markedly with the specimens from California cited above are brought closer to them by somewhat intermediate characters found in the Nevada type. The principal differences from the latter are more slender, less clustered roots, slenderly prolonged outer bract and apparently larger and darker-colored, thinner-walled capsules.

There seems, indeed, good reason to suspect the existence of a group of closely related simple-stemmed species inhabiting nearly the same general region, which on present material it is impossible to disentangle effectually from *S. halophilum* and *S. leptocaulon.*

SISYRINCHIUM LEPTOCAULON Bicknell, Bull. Torrey Club, **26**: 451. 1899.

Sierra Nevada Mts., near Lake Tahoe, *J. Ball*, July 20, 1884 Herb. Acad. Nat. Sci. Phila.

Tuolumne Co.: Soda Springs, Herb. Cal. Acad. Sci.

Lassen Co.: Milford, June 26, 1892, *T. S. Brandegee*, Herb. Cal. Acad. Sci.

The original description of *S. leptocaulon* was drawn from the specimen first above cited together with other material from Nevada and Utah less evidently distinct from *S. halophilum*. Of the additional specimens here recorded, that from Soda Springs, while clearly related to the Lake Tahoe type, shows a greater size for the species and a wider divergence from *S. halophilum* than has hitherto appeared. The stiff, narrowly margined stems are 45–70 cm. tall and about 1.5 mm. wide; the broadest leaves, nearly 2.5 mm. wide, are strongly rather few-nerved and more or less white-glaucous; the bracts are finely close-striate, the outer one stiffly short-pointed, scarcely surpassing the inner, and 2–2.5 cm. long; inner scales crowded, sometimes exceeding the shorter bract; pedicels close-fascicled, somewhat exserted; capsules pale, thick-walled, finely rugulose, 2.5–5 mm. high; seeds 2–3 in a row; a mature seed is nearly 2 mm. in diameter, irregularly compressed-subglobose and very minutely rugulose.

It is impossible to derive a clear understanding of either this species or *S. halophilum* from the scant material so far collected. While extreme examples of each appear obviously distinct, their relationship is confused by certain specimens which cannot be satisfactorily assigned at the present time. As already intimated there is good reason to believe that more than two species enter into the problem.

Sisyrinchium oreophilum sp. nov.

Stems simple, or occasionally developing a single terminal peduncle with subtending leaf, 10–25 cm. high from slender fibrillose roots; pale glaucescent green, showing some discoloration when dry. Leaves about half the height of the stems, firmly erect, becoming rather strongly nerved, 1–3 mm. wide, tapering-acute, the edges smooth; stems .75–1.50 mm. wide, narrowly wing-margined, finely cartilaginous-denticulate to smooth; spathes narrow, the bracts rather prominently but not very closely fine-nerved, the hyaline edges narrow; outer bract 1.5–4 cm. long, narrowly attenuate, abruptly pointed or often obtuse, usually surpassing the inner one 2–10 mm., but sometimes longer, rather closely united-clasping for 5–7 mm. and with sharply keeled edges; inner bract usually abruptly scarious-obtuse and bluntly apiculate; inner scales little more than half the length of the bracts; pedicels erect, slightly exserted, often reddish-purple; flowers violet-purple; perianth 8–10 mm. long, the segments mucronulate-aristulate, slightly if at all emarginate; stamineal column 5 mm. long or less; anthers small, about 1 mm. long; ovary oblong, puberulent; capsule sparsely puberulent, brown, thin-walled, globose or obovoid, 2.5–5 mm. high, many-seeded.

Mariposa County: Yosemite Valley, May–June, 1900, *F. T. Bioletti*, Herb. Cal. Acad. Sci. (type); Yosemite Valley and Mountains, *J. Torrey*, 1865, Herb. Columbia Univ.; Sierra Nevada Mountains, 8,000 ft., south fork of San Joaquin River, July, 1900, *H. M. Hall & H. P. Chandler, no. 652.*

Placer County: Downer Lake, July 25, 1895, *Edward L. Greene*, Herb. E. L. G.

Modoc County: 1894, *M. S. Baker and Frank Nutting*, Herb. E. L. G.

Appearing nearer to *S. angustifolium* than any species seen from west of the Rocky Mountain region, and variously suggestive, as well, of some of the simple-stemmed western species, but showing material differences from each one. It is a smaller plant than *S. angustifolium* with less unequal and more obtuse bracts of somewhat different nervation, smaller flowers with small anthers and more glandular-puberulent ovary, the capsules also more or less sparsely puberulent.

In the relative length of the bracts this species nearly agrees with *S. occidentale*, but it differs notably in much smaller flowers, less acute and differently shaped bracts, especially the narrower inner one, weaker and less narrowly margined, mostly rough-edged stems and more slender roots.

S. segetum is also much larger flowered, as well as taller and more slender, more densely tufted, narrower leaved and with slenderly very acute bracts.

S. halophilum and *S. leptocaulon* both differ essentially from *S. oreophilum* by their thicker roots and smaller, thicker-walled, pale capsules.

The only other simple-stemmed species of any of the Pacific states, *S. idahoense* and *S. sarmentosum*, need no comparison with *S. oreophilum*, the former being a much larger plant in every way, and the latter differing conspicuously by its narrowly prolonged foliaceous bracts, besides narrower and weaker leaves and stems and smaller flowers.

Sisyrinchium Greenei sp. nov.

Mostly 25–45 cm. high, from fibrous, sometimes slightly thickened roots, pale or glaucescent green, often darkening or becoming brownish in drying. Leaves commonly about half the height of the plant and 1–3 mm. wide, sometimes rather thin and soft or becoming firm, varying from linear-attenuate and straight to acuminate and somewhat curved, narrowly acute, the delicate nerves approximate, or becoming well separated on the broader leaves, the edges smooth; stems commonly terminated by one or two, or even three, slender but mostly short peduncles subtended by a usually shorter erect bractal leaf, sometimes bearing a leaf and axillary peduncle lower down, casually simple with terminal spathe, 1–3 mm. wide, narrowly thin-margined or winged, the edges smooth or obscurely denticulate near the node; peduncles 3–10 cm. long, often extremely slender, slightly diverging and mostly a little unequal; spathes often purplish, usually narrow, 15–20 mm. long, the bracts rather firmly fine-nerved, equal, or either one slightly the longer, the outer one mostly acute, sometimes slightly foliaceous and becoming 2.5 cm. long, united-clasping below for .05–.07 mm., the inner one often scarious, obtuse; inner scales mostly about three-fourths the length of the bracts; flowers on slender, slightly exserted pedicels, delicate, pale violet-blue, about 10 mm. long, the segments short-aristulate; stamineal column 5–6 mm. long; ovary glandular-puberulent; capsule subglobose or obovoid, brown, firm-walled, 3–7 mm. high; seeds numerous, apparently medium-sized.

Sierra Nevada Mountains from about midway in the state northward, extending into Oregon, ascending to at least 6,000 feet. Flowering mostly in June and July, although beginning to bloom in May, or even earlier, at lower altitudes. Named in honor of Professor Edward L. Greene.

Siskiyou County: North side of Mount Shasta, 5–9000 feet, June 11–16, 1897, *H. E. Brown, no. 351* (type).

Modoc County: June 14, 1893, *M. S. Baker*.

Plumas County: Near Pratville, Mountain Meadow, 5,500 ft., July 2, 1897, *M. E. Jones;* July, 1896, 1897, 1898, *Mrs. R. M. Austin*.

Butte County: Little Chico Creek, May, 1896, Colby, July, 1896, *Mrs. R. M. Austin*.

Placer County: Applegate, May, 1899, *Mrs. Helen Smith*.

An inhabitant of the mountainous region of the north and northeastern part of the state, there replacing *S. bellum* of the coastwise counties and ascending to high altitudes.

It is ordinarily a smaller, more delicate plant than *S. bellum*, paler green in color and drying paler, and with much smaller flowers. So considerable, however, are the variations shown by the series of specimens at present necessary to refer to this species that little doubt need be entertained that more than one species is involved. Confident segregation, however, must await critical study of more complete material.

The type of *S. Greenei* may be taken as H. E. Brown's *no. 351*, from Mt. Shasta, of which I have seen four good sheets from as many herbaria and which is somewhat intermediate between extremes of the series.

Certain specimens from high elevations in Plumas County, as well as from Klamath Lake, Oregon (July, 1893, *Mrs. R. M. Austin*), are extremely delicate and slender throughout and bear only one or two terminal peduncles; other specimens are considerably stouter with broader and thinner leaves. A few specimens vary suggestively from the type by unusually long peduncles, broad thin leaves and sharply serrulate stems, and appear also to be earlier-flowering, several specimens having been collected in full flower in the month of May.

A particularly notable specimen more than doubtfully associated with the others here assigned is from near Pentz, Butte Co., collected by *Mrs. C. C. Bruce*, April, 1897 (Herb. Cal. Acad. Sci.), in full flower and with some mature fruit, although typical *S. Greenei* appears not to bloom ordinarily until June and July; these specimens are further remarkable for their greatly elongated stems and leaves, some being 70 cm. high, very pale and glaucous, peduncles in clusters of 2–5, and capsules very large, becoming 7 mm. high.

Sisyrinchium Eastwoodiae sp. nov.

Glaucescent green, often brownish-tinged on the herbarium sheet, 20–60 cm. high; roots clustered, becoming slightly thickened towards the base. Leaves firm, with acute hardened tips, sometimes nearly equalling the stem but more often half its height, 1–3 mm. or even 4 mm. wide, firmly striate-nerved, the edges smooth or, in forms, roughened with minute points; stems erect, often flexuously curved, about the width of the leaves, flattened and narrowly winged to subterete and merely margined, the edges smooth or, in forms, bearing close-set, erect or retrorse cartilaginous points; node mostly one, high up, or sometimes two, its leaf shorter than the peduncles, often very short, stiff and bract-like; peduncles one to four, mostly short but sometimes very slender, 3–10 cm. long; spathes narrow, flattened, 1.3–2 cm. long, the bracts finely, but not very closely striate-nerved, the inner one commonly the longer and acuminate or apiculate from a scarious apex, the outer one cuspidate or stiffened to a short corneous tip, united-clasping for 4–8 mm. at base; inner scales equaling the shorter bract or sometimes much shorter; flowers rather numerous, 8–14, on erect or slightly spreading exserted pedicels, rather small; perianth 8–12mm. long, the segments broadly short-aristulate from a usually slightly retuse apex, violet-purple, the yellow eye small; stamineal column about 5 mm. long, ovary loosely glandular puberulent; capsule pale or dark brown, subglobose to obovoid or pyriform, thick-walled, sparsely puberulent, small, 2–4 mm. high; seeds 1–4 in each row, about 1.5 mm. in diameter, rugulose.

Valleys and mountains of Southern California extending into Lower California, not apparently reaching the coast; blooms from early May to July or later. Named in honor of Miss Alice Eastwood.

Kern County: Tehachapi, June 22, 1889, *Prof. E. L. Greene;* San Emidio Cañon, October 2, 1894, *Miss Alice Eastwood.*

San Bernardino County: San Bernardino Valley, in meadows. May, 1886, *S. B. & W. F. Parish, no. 663* (type), also 1889 and 1888, by same collectors; San Bernardino, May 3, 1898, *S. B, Parish,* 1880, *G. R. Vasey;* San Bernardino Mountains and their eastern base, alt. 5,000 ft., June 28, 1894, *S. B. Parish, no. 3045.*

San Diego County: San Ysabel, May, 1893, *H. W. Henshaw;* Cuiamaca Mountains, July 12, 1875, *Edward Palmer, no. 374.*

The above description of *S. Eastwoodiae* has been derived primarily from the plant of the San Bernardino Valley represented mainly by the collections of S. B. and W. F. Parish. This is, apparently, the largest form of the species, frequently developing two leaf-bearing nodes, and with the basal leaves mostly about half the height of the close tufts, becoming even more than 4 mm. wide. This plant shows more or less discoloration on the herbarium sheet. It comes into flower in April and May.

Specimens collected by Professor Greene at Tehachapi, still flowering towards the end of June, are tall, pale in color, with long, slender, narrowly attenuate leaves and somewhat flexuous, very firm, smooth-edged stems with a single node and slender peduncle; the bracts of the spathe are narrow and firm, the shorter primary one with a stiff corneous tip.

Near this form may be placed a small, very different-appearing plant collected by Miss Alice Eastwood in San Emidio Cañon, Kern County, still flowering in October. Its leaves are short, especially the nodal leaf, the stems and peduncles very slender, the bracts mostly under 1.5 cm. in length, and the capsules only 2–2.5 mm. high; the outer bract shows the same hardened nail-like tip seen in the Tehachapi specimens.

In the absence of further material for study there may be referred here, also, Dr. Edward Palmer's *no. 374*, collected on mountains in the southern part of San Diego County in full flower, July 12th. These specimens are noteworthy in several ways, especially by reason of the harshly cartilaginous-ciliolate edges of leaf and stem and the roots which are distinctly woody-thickened toward the base; the bracts also appear to be more membranous than in the more northern plant and are mostly very acute, but without an indurated tip.

Another collection from the San Bernardino mountains must for the present find its place here also, although presenting many points of contrast. The stems are but 6–15 cm. high, many of them simple but others bearing two short peduncles; the leaves are short, relatively broad and mainly obtuse as are the broad short bracts, and both stems and leaves are more or less denticulate or even cartilaginous-ciliolate. This plant was collected by S. B. Parish in flower, June 28th, at an altitude of 5,000 ft., and though strikingly at variance with the valley plant may well be a modified sub-alpine form.

Sisyrinchium funereum sp. nov.

Stiff and erect in scant tufts becoming 50–60 cm. high, pale glaucous-green, not discoloring when dry, the dead leaves and stems of the previous season, bleached to a light straw-color, persisting rigidly amid the fresh growth ; roots soft and stout, mostly 2–3 mm. thick towards the base when dried and becoming over 30 cm. long. Leaves somewhat shorter than the stems, very smooth throughout, strongly close-nerved, 2–3.5 mm. wide, narrowly tapering to an acute, hard-pointed apex, their bases broadened and equitant; stems 2–4.5 mm. wide, stiff and straight, narrowly firm-margined and very smooth; node only one, high up, bearing a stiff, erect bracteal leaf 4–10 cm. long, subtending 2–3 longer approximate peduncles; peduncles slender, erect, straight or slightly curved, unequal, 4–12 cm. long; spathes erect or slightly bent, 18–23 mm. long, 2–3 mm. wide; bracts closely approximate, firmly close-nerved, the inner one usually slightly surpassing the outer, its tip white-scarious, obtuse, or even truncate or emarginate and apiculate, sometimes erose-denticulate; outer bract hyaline-margined nearly to the short-pointed apex, broadly so below, united-clasping for 5–7 mm.; inner scales crowded, silvery white, about equaling the bracts in length; flowers numerous, finally 12–18, on slightly exserted puberulent pedicels ; perianth-segments violet-blue, 12–14 mm. long, contracted to a mucronate apex ; stamineal column about 5.5 mm. high; ovary densely glandular-puberulent ; pedicels fascicled, stiff and erect, or somewhat diverging above, the weaker ones sometimes spirally flexuous ; capsules light-colored, thick-walled, 3–6 mm. high, oblong-ovoid to broadly ovoid, often truncately contracted above and below, more or less distinctly moulded over the seeds ; seeds rather few, 2–4 in a row on slender stipels from central placentae, mostly globose and 1.5 mm. in diameter, black, rugulose, reticulate, not umbilicate.

Furnace creek cañon, Funeral Mountains, January 27, 1891, *Frederick V. Coville & Frederick Funston*, Death Valley Expedition of the U. S. Department of Agriculture, *no. 225*.

A striking species, tall and stiff and very pale in color, with appressed peduncles, rather large flowers and greatly developed root-system. The persistence from one flowering season to another of the dried and rigidly erect leaves and stems is a noteworthy characteristic of the plant. It would appear from the single collection of the species so far made that the seeds of one season were carried over to the succeeding one to be released when the plant came again into flower.

SISYRINCHIUM BELLUM S. Watson, Proc. Am. Acad. **12** : 277. 1877.

Remarkably variable in size and relative proportions; from 6 cm. to over 6 dm. high, mostly 2.5–4 dm., green to glaucescent, subject to slight or to pronounced discoloration on the herbarium sheet, the tufts often fibrillose at base, the roots either slender or somewhat thickened, frequently from an ascending or horizontal, sometimes compound, woody rootstock. Leaves soft and rather thin, or becoming firm, finely many-nerved, sometimes equaling the plant in height but usually shorter, mostly 2–4 mm. wide (1–6 mm.), acute or aculeate, the edges smooth or denticulate; stems erect, stout or slender, 1–4 mm. wide, narrowly firm-margined to narrowly winged, the edges smooth or denticulate; sides of leaves, bracts and stems rarely obscurely roughened with harsh points; primary node supporting from 2–4 peduncles or one or two branches each with 1–2 peduncle-bearing nodes; primary stem-leaf conspicuous, the bracteal leaves usually much reduced; peduncles stout or very slender, straight or curved, divergent or erect, sometimes very short but becoming 18 cm. long; spathes very variable, linear, lanceolate, or short oblong, 1.5–6 mm. wide when pressed, the bracts green or purplish, very acute to obtuse, straight to strongly incurved, subequal or very unequal, when subequal 1.5–3 cm. long, when very unequal foliaceous and reaching a length of 3.5 cm. for the inner and 5.5 cm. for the outer bract; bracts finely many-nerved, the edges often conspicuously white or purplish margined, the outer one united-clasping below for from ¼ to ½ its length; inner scales mostly brownish tinged, sometimes equaling the bracts, but usually much shorter; flowers on slightly or slenderly exserted erect or diverging pedicels, varying in color from blue and violet to lilac, in light and dark shades, in one specimen pure white; segments sharply emarginate or contracted to the mucronate or aristulate apex, 12–20 mm. long; column 5–7 mm. high; ovary glandular-puberulent to glabrous; capsules dark or pale brown, depressed-globose to obovoid or pyriform, in some forms strongly trilobulate, 2–7 mm. long; seeds 1 or 2 to 5–6 in each row, about 1.5 mm. in diameter, dark, pitted, subglobose.

Apparently common in all the coastwise counties from San Diego to Mendocino, extending from the immediate coast back into the mountains, but no evidence has developed of its occurrence in any of the inland counties.

In the southern part of the state the species begins to flower in February and March, and sometimes even in March in the neighborhood of San Francisco. At its northern limit flowering begins in May and June, continuing into July and August.

San Diego County: San Diego, 1850, *C. C. Parry;* May, 1852, *Geo. Thurber;* April, 1866, *Weed;* 1882, *C. G. Pringle;* 1884, *C. R. Orcutt;* 1885, *E. L. Greene;* February 19, 1891, *Alice Eastwood;* Delmar, April 16, 1895, *Belle S. Angier;* Fall Brook, March 17, 1882, *Marcus E. Jones.*

Los Angeles County: Los Angeles, April, 1888, *Dr. H. E. Hasse;* March 14, 1890, *Fritchley;* San Gabriel, March 23, 1854, *Dr. J. M. Bigelow.*

Santa Barbara County: Santa Barbara, 1874, *Miss S. P. Monks.*

Monterey County: Santa Lucia Mountains, August, 1885, *T. S. Brandegee;* April, 1898, and May 20, 1897, *R. A. Plaskett.*

Santa Cruz County: *Horace Davis.*

San Mateo County: Purisima, April, 1898, Blenheim, May 19, 1901, *Alice Eastwood.*

Alameda County: Salinas Plains, March, 1866, *A. Wood;* Berkeley, 1882, 1886, *E. L. Greene;* 1892, *Michener & Bioletti;* Point Isabel, June, 1900, *Alice Eastwood.*

San Francisco County: near San Francisco, *Dr. A. Kellogg*, 1866; March, 1892, *Michener & Bioletti;* May, 1894, *Alice Eastwood.*

Marin County: April, 1895, *Alice Eastwood.*

Solano County: 1866, *A. Wood;* Bernicia, *Rev. J. P. Moore.*

Sonoma County: *E. Samuels;* Bodega Point, July 4, 1900, Hood Mountain, April 27, 1893, Altruria, April 7, 1900, *Alice Eastwood.*

Mendocino County: Long Valley, 1871; May, 1898, June, 1898, *H. E. Brown;* Red Mountain, Strong Mountain, May 21–28, 1902, Fort Bragg, August 9, 1902, *Alice Eastwood.*

Although no specific type of *Sisyrinchium bellum* is cited by Dr. Watson, a number of sheets labeled by his hand are preserved in the Gray Herbarium. Among these are excellent examples of the stout and large-flowered coastwise plant which Dr. Watson's description furthur unmistakably defines. There need be no doubt, therefore, as to the right application of the name *Sisyrinchium bellum*, notwithstanding the existence of several sheets so labelled by Dr. Watson, which, as it now appears, really represent other species.

Even as here delimited, however, *S. bellum* is still quite certainly an aggregate, and certain further lines of subdivision not yet clearly shown may confidently be expected to reveal themselves to careful field observation and the study of ample material.

In the more southern coastwise counties of the state occurs a form commonly more tufted, smaller and more branched than the type, often more fibrillose about the base and usually turning much darker on the herbarium sheet; other comparative differences appear in very slender erect peduncles, smaller spathes with subequal often sharply apiculate or aculeate bracts, smaller flowers and small, dark, trilobulate capsules only 2–4 mm. high.

In marked contrast with this is another form apparently confined also to the southern coastwise counties which discolors less when dry and is tall and stout, with rather short, curved peduncles, short, oval spathes with mostly equal, often obtuse bracts, and apparently larger flowers with broader less slenderly aristulate segments.

Similar to the type, but usually lower and less branched and with shorter peduncles, is a form apparently best developed somewhat northward in the range of the species which is noteworthy for its conspicuously foliaceous and often greatly elongated unequal bracts; in this plant the ovary is sometimes, at least, quite glabrous.

Also from northward in the range of the species, especially from Mendocino County, come a few specimens very slender throughout having mostly two slender approximate peduncles, narrow, very acute bracts, much exserted pedicels, the flowers with narrow segments, and small, subglobose, few-seeded capsules.

Still further rather suggestive indications of other species are afforded by certain imperfect or fragmentary specimens of little use to discuss at the present time.

Sisyrinchium hesperium sp. nov.

Slender, erect or ascending in thin, somewhat open tufts sparsely fibrillose at base, 25–40 cm. high, dull green and glaucescent becoming brownish in drying, the slender roots numerous and densely clustered. Leaves thin and soft or becoming firm, half the height of the stem or less, 1–3 mm. or even 4 mm. wide, usually narrowed towards the base, tapering-acute, straight or slightly falcate, the edges smooth or obscurely denticulate-roughened; stems fragile, 1–2.5 mm. wide, merely margined, or with narrow finely nerved wings, the edges smooth or slightly denticulate; peduncles 1–3, erect or diverging, long and very slender, 5-14 cm. in length; spathes narrow, 15–25 mm. long or the outer bract longer; bracts membranous, narrow, often attenuate, delicately nerved, mostly cuspidate-acute and often narrowly aristulate, distinctly white-margined, the outer one united-clasping below for 5-10 mm., sometimes for half its length; inner scales narrow, attenuate, about three-quarters the length of the bracts; flowers on hair-like exserted pedicels, deep violet-purple, perianth about 10 mm. long; stamineal column about 5 mm. long; capsules often on flexuously spreading pedicels, brown, thin-walled, obovoid-pyriform to subglobose, 3–5 mm. high, slightly puberulent; seeds only 2–4 in each row, large, becoming 1.5 mm. or more in diameter, rugulose.

Near the boundary between Santa Barbara and San Luis Obispo Counties, Dutard's Ranch, May 9, 1896 (type).

Fresno County: Wauthan, May 11, 1893.

Monterey County: Melpitas Ranch, Santa Lucia Mountains, May 1-12, 1899.

All in flower and early fruit and collected by *Miss Alice Eastwood.* In Herb. Cal. Acad. Sci.

A much more slender and delicate species than *S. bellum*, often very fragile, with long, very slender peduncles, smaller, more delicate flowers on hairlike, mostly flexuously exserted pedicels, and smaller, thinner-walled capsules.

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Lists of titles of Contributions may be had on application.

LUCIEN M. UNDERWOOD,
Professor of Botany.

COLUMBIA UNIVERSITY,
NEW YORK CITY.

CONTRIBUTIONS FROM THE DEPARTMENT OF
OF COLUMBIA UNIVERSITY—No.

THE POLLEN TUBE IN THE CUCURBITACEAE AND RUBIAC

By FRANCIS E. LLOYD

NEW YORK
1904

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THE GIFT OF

THE POLLEN TUBE IN THE CUCURBITACEAE AND RUBIACEAE

BY FRANCIS E. LLOYD

In a recently published paper * Longo has given us the very interesting results of his later investigations on the behavior of the pollen tube in the Cucurbitaceae. The close similarity of the facts presented by Longo to those which have been observed by myself in Rubiaceae, † and the parallelism of our conclusions, will, perhaps, warrant a brief comparative statement of our results.

According to Dr. Longo, the ovary in *Cucurbita Pepo* L. is provided with a special conductive tissue which arises, by tangential cell-division, "from the epidermis of the placental ridges and extends uninterruptedly from the style, through the three central laminae, to the ovule." The placentae, of course, fuse along their surfaces with one another, so that the layer of conductive tissue between any two of them is derived from two epidermal cell-layers, and is continuous transversely, as well as longitudinally.

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* Longo, B. Ricerche sulle Cucurbitaceae e il significato del percorso inter cellulare (endotropico) del tubetto pollinico. R. Accad. Lincei, Va, **6** : 523–547. *pl. 1–6.* 1903. ["Presented in December, 1902." Bot. Centralb. **95** : 114. 1904.]

† Lloyd, F. E. The Comparative Embryology of the Rubiaceae. Memoirs Torrey Botanical Club, **8** : 27–112. *pl. 5–15.* 15 F 1902.

The tissue consists, moreover, of small sub-isodiametric cells, rich in contents, and *not lengthened in any direction* in particular. They lack, therefore, the anatomical characters found generally in stylar conductive tissues, and are in form, at least, like the cells which lie in portions of the path of the pollen tube in *Casuarina*, certain Amentiferae, *Alchemilla* and in a number of other plants.*

The conductive tissue is further extended between the ovules, being interrupted by their funicles, and comes *to abut upon their nucelli.* This is brought about by the circumstance that in *Cucurbita Pepo* the nucellus has the shape of a flask, the long neck of which extends through and protrudes beyond the micropyle, its end coming into contact with the conductive tissue. It thus comes about that there is, in this species, *no free locular space*, but rather a continuous stretch of conductive tissue from the stigma to the embryo sac. What would be inferred, namely, that the pollen tube must therefore have a completely intercellular course, is indeed the case, as Longo has demonstrated.

In the other genera studied, on the other hand, *e. g.*, *Citrullus vulgaris*, Schrad. (which Longo figures), the nucellus has but a short neck, which leaves open a micropylar canal of considerable extent. From these, too, is absent the conductive tissue described for *Cucurbita Pepo*, there being instead an ovarian space. Through this, and through the micropyle, the pollen tube grows freely in its path to the nucellus, where, however, as in many other plants, it must enter upon a short intercellular course in order to reach the embryo sac. It thus appears that, *in two closely related genera in the same family, and indeed in different species of the same genus, the pollen tube differs in its behavior, in that, in the one case its course is throughout intercellular, while in the other it moves freely in a cavity.*

In every other species of this genus, *Cucurbita*, the nucellus is too short to reach quite up to the conductive tissue (*e. g.*, *C. maxima*, *ficifolia*, *foetidissima*) and in these, the pollen tube moves freely in the cavity thus formed in reaching the nucellus.

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* For citations of the pertinent literature, see either of the papers above indicated.

There are, in addition to the above, some further details of interest in regard to the pollen tube. Its path, as described by a number of observers for other plants, lies between the cells of the conductive tissue in all cases. In *Cucurbita,* upon reaching the base of the neck of the nucellus, it enlarges to form a "bulla" of considerable size. Furthermore, this bulla in some cases produces lateral cul-de-sacs, which extend into the surrounding tissues, after the manner of the lateral suspensor tubes in certain orchids * and in the Galieae among the Rubiaceae.† It further appears that the production of these lateral outgrowths of the "bulla" is correlated with the supply of starch in these surrounding tissues, since, when starch is absent, none are formed, and when abundantly present, the tubes are most extensively developed. Their use, therefore, according to Longo, is to reach out after food materials, which he believes are then passed on to the embryo, as a nutritive supply for its growth.

The conclusion that there is a correlation between the growth of the bulla and the presence of starch, the extent of the former being in direct proportion to the presence of the latter, appears to be supported by Longo's observation that, when pollen grains are grown upon gelatine, bullae are formed, while, when they are allowed only moist air, they fail. These results are analogous to those of van Tieghem obtained for *Ricinus* and *Symphytum.* Van Tieghem, however, used gum arabic instead of gelatine. In *Elodea Canadensis,* however, according to R. B. Wylie, ‡ the pollen tubes which enter the ovarian cavity sometimes fail to reach the micropyle, and these produce "cystoids" which are usually found to be quite free in the locule. Wylie further notes that these "cystoids," which, it would seem, so far as we can at present see, are not different from the structures observed by Longo and van Tieghem, are never produced in the tissues, where, without doubt, food materials occur in greater abundance, however little their actual amount, than in the ovarian cavity. We must therefore conclude, in the absence of further evidence that this behavior may not wholly be determined in the manner asserted by Longo.

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* **Treub, M.** Notes sur l'embryogénie de quelques Orchidées. Naturk. Verh. K. Akad. 19 : —. 1879.

† Lloyd, F. E. *Op. cit.*

‡ The Morphology of *Elodea Canadensis.* Bot. Gaz. 31 : 1–22. Ja 1904.

In discussing the facts above outlined, Longo draws the following conclusions:

1. The behavior of the pollen tube in following an intercellular path is not connected with its inability to grow freely in an open space. This is to be inferred from the fact that in closely related species the behavior in this respect is different according to the continuity of the conductive tissues. Longo has completely demonstrated the truth of his contention, by showing that the pollen of *Humulus Lupulus* L., and of *Cannabis sativa* L., * in all of which the pollen tube has an endotropic course, germinates in humid air, and pollen tubes are produced. Experimental evidence was obtained in the case of the pollen of certain gymnosperms (*Picea excelsa*, three spp. of *Pinus*) which also germinated and produced tubes in moist air, from which he correctly inferred that the endotropic behavior in angiosperms cannot be due to an inheritance of this trait in the gymnosperms, as was pointed out by Murbeck.† Clearly, we must, as Longo maintains, abandon the position that the phenomena of ectotropism and endotropism are quite distinct from each other.

2. Chalazogamy is not primitive in the angiosperms, and this, or in general, the intercellular behavior, is a later phenomenon, and in this, Longo differs from Treub and Nawaschin, but agrees with Murbeck, who regards such behavior as a physiological peculiarity, and of no meaning from a phylogenetic point of view.‡

3. In plants in which the pollen tube is endotropic, the direction of its growth is determined by the presence of a special substance to which it responds chemotactically. This, Longo adds, is developed within the tissues when the course is endotropic

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* Longo, R. *Op. cit.*, p. 21.

† Murbeck, Sv. Ueber das Verhalten des Pollenschlauches bei Alchemilla arvensis. Lands. Univ. Arsskrift, 36: 9. 1901.

‡ Murbeck, Sv. *Op. cit.*

and on their surfaces when the course is superficial. This conclusion is drawn from the circumstances that the pollen tubes of *Humulus* and *Cannabis*, when growing upon a cover-glass in humid air, are indeterminate in the direction of their growth.

We may now turn to the facts concerning the behavior of the pollen tube in the Rubiaceae. The plants which offer these are *Richardsonia pilosa*, *Diodia teres*, and *D. Virginiana*. The ovary in *Richardsonia* is trilocular, in *Diodia*, bilocular. In all three there is a single ovule in each locule, and this is inserted at the top of the basal element of the partition which separates the locules. This partition reaches to the middle height of the ovary, and the separation of the locules from this point on is completed by the stylar elements. The latter has a conductive tissue of elongated cells, which extends to its point of fusion with the basal element of the partition. Up to this point in all three the course of the pollen tube is direct and endotropic. After this, however, it is quite different, in *Richardsonia* and *Diodia teres* on the one hand, and *D. Virginiana* on the other. The ovule in *Diodia Virginiana* has a tract of epidermal conductive cells which are cubical in form, on the outer surface of which is secreted a mucilaginous substance. On the surface of these cells, the pollen tube moves freely till it reaches the micropyle, which it enters and traverses till it reaches the embryo sac. The conductive tissue is confined to a strophiolar outgrowth of the ovule.

In *Richardsonia* and *D. teres*, however, the ovules are provided with a conductive tissue of deeply columnar epidermal cells, with dense protoplasmic contents, and thick but soft and yielding walls. There is, however, no mucilaginous secretion to be found upon their exposed ends. In these plants, the course of the pollen tube is always (*Diodia teres*) or nearly always (*Richardsonia*) completely endotropic. The pollen tube grows between the epidermal cells, as in the Cucurbitaceae, and follows a direct path toward the micropyle at right angles to the direction of least resistance. Aside from the latter fact, we have, it is seen, *two closely related genera, and two species of one of these, in which the behavior of the pollen tube is different, in that, in one species the course is ectotropic, and in the two others, distributed in different genera, the course is endotropic.*

The following conclusions have been inferred by me from the above observations:

1. The form of the cells which compose a conductive tissue can have no importance in directing the pollen tube, though they may deflect it here and there in its course. This is clear from the circumstance that we have in two of the species studied, a conductive tissue, the cells of which are elongated at *right angles to the path* of the tube. We must therefore conclude that the guidance of the pollen tube through the tissue is due to a chemotactic stimulus, thus confirming the view of Molisch and with which Longo finds agreement. In order, however, to determine *direction*, the stimulant must, I have maintained, be distributed differentially, from a center toward which, therefore, the pollen tube must grow. I now believe that the egg cell is the origin of this substance.

2. The behavior of the pollen tube, whether ectotropic or endotropic, is a purely physiological character. When the mechanical conditions make it necessary, as, *e. g.*, in *Cucurbita Pepo*, and as I have shown in *Diodia teres*, the path of the pollen tube is wholly endotropic; when, however, there is a free space to move in, this may be used by the pollen tube, or if the distribution of the chemotactic stimulant is otherwise, the free space may be avoided. By inference, the phylogenetic interpretation of endotropism advanced by Treub and Nawaschin is of no further importance.

For other facts and conclusions, less relevant to our present purpose, the reader may be referred to the original papers. It is of no small interest that almost precisely parallel facts have been brought to light independently by two different observers, and that, equally independently, the same significance has been attached to these facts.

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LUCIEN M. UNDERWOOD,
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NEW YORK CITY.

CONTRIBUTIONS FROM THE DEPARTMENT OF BO
OF COLUMBIA UNIVERSITY—No. 211

THE DAILY PERIODICITY OF CELL-DIVIS
AND OF ELONGATION IN THE ROOT OF AL

BY WILLIAM E. KELLICOTT

NEW YORK
1904

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 31: 529-550. October,

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 31 : 529–550. October, 1904.]

The daily periodicity of cell-division and of elongation in the root of Allium

WILLIAM E. KELLICOTT

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1. Introduction

It is a well-known fact that rhythmic variation in the rate of growth is widespread, perhaps universal. It is similarly known that the nature of the rhythm varies considerably in different plants, so that there is no uniform hour at which the rate of growth is highest or lowest: each form seems to have its own peculiar rhythm. Perhaps this is one reason why there is at present so little uniformity of opinion among those who have studied the phenomena of growth in various plants, as to the factors involved in the production and maintenance of this rhythm. One possible factor has been overlooked almost entirely, namely, that of cell-division. As a matter of fact very little is known concerning the actual relations between cell-division and growth. Practically the only record of any observed correlation between cell-division and elongation is that of Ward,* who observed that, in *Bacillus ramosus*, "the period of cell-division entails more or less cessation of growth" (page 294), and that (pages 301–2) "periods

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*Ward, H. M. On the biology of *Bacillus ramosus* (Fraenkel), a schizomycete of the river Thames. Proc. Roy. Soc. **58** : 265–468. 1895.

of slowest growth . . . were the approximate moments of insertion of the septa, and consequently, moments when elongation would be going on with the least rapidity. . . ." Concerning the correlation of these processes in higher forms nothing at all is known.

Not only has there been no real attempt to correlate the processes of elongation and cell-division in a given organ, but there is a complete lack of knowledge concerning the course of cell-division alone in a growing part. And while much is known with regard to the daily rhythm of elongation or growth of organs, in nearly every instance the organ observed has been aërial and therefore subject to very profound and rapid environmental disturbances accompanying the alternating conditions of day and night. As far as can be discovered the only observations on the daily periodicity of growth of subterranean parts are those of Strehl* on the roots of *Lupinus*, and MacMillan † on the potato-tuber.

It seems, therefore, that here is an opportunity for profitable investigation: to determine whether there is a rhythmic daily variation in the rate of cell-division of a growing organ; to determine whether there is a definite daily rhythm in the growth or elongation of a subterranean part which is growing under much more uniform conditions than the aërial parts; and finally, if such rhythms are found to exist, to determine whether there is any correlation between the processes of cell-division and elongation. The observations described in this paper were designed to attack these questions, and it is believed that the results have been definite enough at least to warrant further serious investigation.

I wish to take this opportunity to express my very considerable indebtedness to Dr. C. C. Curtis, Columbia University, under whose direction these observations were carried out, for his ever ready aid and valuable counsel.

2. Summary

The principal facts brought out in this paper are the following:

1. In the root of *Allium* there are two maxima and two minima in the rate of cell-division during twenty-four hours.

---

* Strehl, R. Untersuchungen über das Längenwachsthum der Wurzel und des hypokotylen Gliedes. Leipzig, 1874.

† MacMillan, C. On the growth-periodicity of the potato-tuber. Am. Nat. 25: 462–469. 1891.

2. The primary maximum occurs shortly before midnight (11 p. m.) and the primary minimum about 7 a. m. The secondary maximum occurs about 1 p. m. and the secondary minimum about 3 p. m.

3. There is no correspondence between the rate of cell-division and slight variations in temperature.

4. In the root of *Podophyllum*, maximal and minimal points occur at almost the same hours as in *Allium*.

5. Tap-water alone or with various substances in solution, seriously affects the course of cell-division. In some cases there may be recovery and partial return to the normal condition.

6. Under normal conditions of growth, the rate of elongation of the root of *Allium* exhibits a daily rhythm showing two maxima and two minima during twenty-four hours.

7. Elongation is most rapid (primary maximum) about 4 or 5 p. m., the secondary maximum occurring about 7 a. m. The primary minimum is about 11 p. m. and the secondary minimum about noon.

8. Periods of rapid cell-division coincide with low rate of elongation, and during rapid elongation the rate of cell-division is lowest.

3. Methods

(*a*) CELL-DIVISION

Sound average-sized bulbs of *Allium* were selected and allowed to germinate at ordinary room-temperature in moist sand or pine sawdust until the roots were from 50 to 100 mm. in length: this was usually after from four to six days. Then at definite intervals, usually of about two hours, throughout 24-hour periods, two root-tips from different parts of the bulb were taken for examination. The tips were fixed 20 minutes in acetic-alcohol (glacial acetic 1 part, 70 per cent. alcohol 2 parts), sectioned longitudinally 10 microns thick, and stained in Delafield's haematoxylin.

It is believed that the method used in determining the relative numbers of dividing cells in the different tips entirely obviated error due to differences in the size of the tips. From each, the three sections passing nearest the axis of the root were selected and the area to be examined determined in the following way. At a distance of 5 micrometer spaces (eye-piece micrometer ruled in millimeters, ocular 3, objective Zeiss A, tube-length 140 mm.) from the growing point of the tip (the root has attained a uniform diameter at this point) its diameter was measured carefully. An imaginary line was then drawn across the section at a distance from its extremity of twice its diameter. The area examined was that below this transverse line (FIGURE 1), and was found in every instance to contain practically all of the actively dividing cells of the undifferentiated tissue.

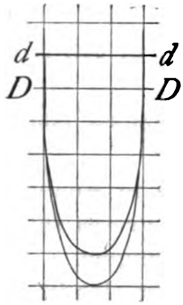

FIGURE 1. Diagram showing method of measurement. *DD*, diameter 5 spaces from apex. Area examined extended to line *dd*. Area of this tip = 15.

The number of dividing cells within the corresponding areas of the three selected sections was then carefully counted. The dividing cells were tabulated in three groups. The first group included those cells in the early stages of mitosis up to the time of the formation of the equatorial plate, *i. e.*, all stages of the prophase. The second group included those cells in metaphase and early anaphase up to the time when the divergence of the chromosomes is complete. The last group included the cells in late anaphase up to the time of the reconstruction of the nucleus and formation of the new cell-wall. These groups were then added and the average of the three sections taken as the number characteristic of the tip.

In order to avoid error due to the comparison of tips of different sizes the areas of the sections were reduced to a common area and the proportional numbers of dividing cells calculated. The average area of the sections was about fifteen micrometer squares; therefore the numbers of cells in sections having larger or smaller areas than this were calculated proportionally.

This method of comparison is justified by the fact that the size of a part or organ is determined by the number of cellular elements contained in it and not by variations in their size.* Several counts were made in given areas of large and small root-tips of *Allium*, and this was found to be true.

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* Amelung, E. Ueber mittlere Zellengrösse. Flora, 77: 176. 1893.—Strasburger, E. Histologische Beiträge. 5: 117–118. 1893.

The series of *Podophyllum* used as a check, were treated in the same manner except that the smaller size of these tips necessitated their reduction to an average area of nine micrometer spaces.

(*b*) ELONGATION

In determining the periodicity of elongation the method of direct observation was used. Onions were grown in pine sawdust in pots with a narrow glass slip set in one side. Roots frequently grew almost vertically along this glass and would be exposed properly to moisture and air in the pot. These bulbs were of course grown entirely in the dark-room. When the roots were about 35–40 mm. long they were observed by candle-light through a horizontal microscope and the temperature recorded, at one- or two-hour intervals during a 24-hour period.

4. Daily periodicity of cell-division

A. UNDER NORMAL CONDITIONS

(*a*) *Typical observation.*—We shall consider first the rhythm of cell-division under normal circumstances of growth. To illustrate more fully the method employed and to furnish a basis for comparison, one of the records has been reproduced completely in TABLE 1.

This table shows that by far the larger proportion of cells in the process of mitosis were in the prophase, as would be expected, since the preparation for and inauguration of mitosis occupy a much longer period than the later phases, which are passed through very rapidly. The table shows also how remarkably similar are the conditions of the root-tips examined at the same hour. This similarity is much closer than was expected on account of the numerous factors liable to cause individual variations. It will be seen that at 9 a. m., 11 a. m. and 1 p. m., for example, the numbers of dividing cells are almost identical in the two tips, while only in a few instances, such as at 5 p. m., 9 p. m. or 1 a. m., were there differences at all considerable.

The final averages of this table are represented in the form of a curve in FIGURE 2, *curve I*, which shows graphically the rate of cell-division during a 24-hour period. The curve is remarkably regular, with two maxima and two minima. Cell-division is most rapid (primary maximum) at 11 p. m., the secondary maximum

TABLE I

NUMBERS OF DIVIDING CELLS IN ROOTS OF SINGLE BULB OF ALLIUM

Time.	Temperature.	Area examined	Dividing cells.			Total dividing cells.	Total reduced to area=15.	Average for each tip.	Average of two tips.
			Early.	Middle.	Late.				
9 a. m.	16°	11.5	25	9	1	35	46	47	47
			23	8	4	35	46		
			30	5	3	38	50		
		13.5	33	3	3	39	43	47	
			36	2	4	42	47		
			37	3	5	45	50		
11 a. m.	17°	12.5	28	10	6	44	53	54	54
			33	8	6	47	56		
			27	9	8	44	53		
		12—	28	7	2	37	47	53	
			38	11	4	53	66		
			24	5	4	33	45		
1 p. m.	17.5°	13	46	4	4	54	62	61	62
			47	2	2	51	59		
			49	2	2	53	61		
		15.5	58	4	6	68	66	63	
			53	3	8	64	62		
			49	4	9	62	60		
3 p. m.	27°	12.5	26	2	3	31	37	39	35
			29	1	2	32	38		
			33	1	1	35	42		
		12	23	0	3	26	33	31	
			21	0	3	24	30		
			21	1	1	23	29		
5 p. m.	19°	13.5+	24	3	3	30	33	33	50
			26	2	2	30	33		
			25	2	2	29	32		
		11.5	37	4	6	47	61	67	
			46	1	3	50	65		
			45	6	6	57	74		
7 p. m.	17°	12	43	2	9	54	67	65	62
			39	4	8	51	64		
			38	3	10	51	64		
		13	42	2	4	48	55	59	
			47	4	4	55	63		
			45	1	6	52	60		
9 p. m.	15°	14	47	6	1	54	58	67	75
			53	8	4	65	70		
			65	2	0	67	72		
		13+	64	2	3	69	79	83	
			72	2	3	77	88		
			65	3	4	72	82		
11 p. m.	14.5°	11.5	65	3	4	72	94	93	89
			64	5	7	76	99		
			60	3	4	67	87		
		13	62	3	3	68	78	86	
			70	4	5	79	91		
			69	3	4	76	88		

TABLE I—*Continued*

NUMBERS OF DIVIDING CELLS IN ROOTS OF SINGLE BULB OF ALLIUM

Time.	Temperature.	Area examined.	Dividing cells.			Total dividing cells.	Total reduced to area=15.	Average for each tip.	Average of two tips.
			Early.	Middle.	Late.				
1 a. m.	14°	13—	37	1	1	39	45	48	57
			38	2	3	43	50		
			33	4	5	42	48		
		11+	45	5	2	52	69	66	
			40	2	3	45	60		
			44	5	2	51	68		
3 a. m.	14°	15	31	2	2	35	35	40	42
			35	3	2	40	40		
			35	8	1	44	44		
		17+	48	1	6	55	47	44	
			46	0	2	48	42		
			44	0	5	49	43		
7 a. m.	18°	16	23	1	2	26	24	24	24
			26	1	1	28	26		
			22	2	1	25	23		

occurring at 1 p. m. The primary minimum in the rate of cell-division occurs at 7 a. m. following the primary maximum, the secondary minimum at 3 p. m. following the secondary maximum.

Thus there are two regular waves of cell-division during each twenty-four hours, a more extensive wave extending from late in the afternoon until early in the morning, and occupying therefore practically all of the dark period; its crest occurs shortly before midnight. A less extensive but otherwise similar wave occupies the light period of the day extending from early morning until late in the afternoon. The crest of this wave occurs about noon. Both of these waves are remarkably regular with only the slightest secondary fluctuations.

The temperature of the air around the bulbs is recorded in the same diagram. It will be seen that there is no correspondence between these slight variations in temperature and the rate of cell-division.

(*b*) *Comparisons of other observations.* — FIGURE 2 includes curves derived similarly from two other series of root-tips. *Curve II* is introduced simply as another illustration of the normal type of curve such as *curve I.* Here the tips were cut less frequently so that all points of *curves I* and *II* do not correspond exactly.

The primary maximum occurs at 8 p. m., the secondary maximum at noon; the primary minimum at 5:30 a. m. and the secondary minimum at 5 : 30 p. m. It is unnecessary to give further examples of this character; in general it was found that under normal conditions of growth, cell-division was most active an hour or two before midnight and about noon, and was least active about 6 a. m. and 4 p. m.

Curve III in FIGURE 2 is introduced with its accompanying temperature curve to illustrate a very peculiar exception to this general rule. Cell-division here followed a perfectly normal course until just after the period of the primary maximum. Then instead of falling steadily to the primary minimum, it increased rapidly and reached a maximum far above that shown by any other series, at about the time when all other series showed the most pronounced minimum, *i. e.*, at 6 a. m. Then falling to its normal rate it proceeded after the typical fashion. That the rhythm of this plant was rendered abnormal in the prolongation of its most active period by some unknown conditions is evident. No other series showed any variation of this nature nor nearly of this extent. The curve is introduced here to show that when the usual rhythm of cell-division is interfered with, the normal rhythm

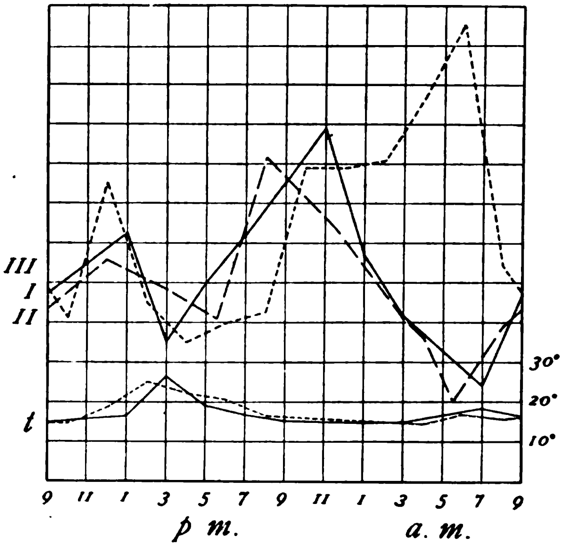

FIGURE 2. Cell-division in root of *Allium*. *t*, temperature.

tends to recur when the disturbing factor is removed or overcome. The fact that the specific cause of the disturbance is unknown in this instance does not lessen materially the value of the evidence.

(*c*) *Comparison of observations on Podophyllum.* — We may now review briefly the results obtained from a similar examination of the rhythm of cell-division in the root of *Podophyllum*. This form was selected to be compared with *Allium* because it too had very large cells, rapidly and easily grown roots, and because it was a representative of a totally different subclass. The method used was the same as with *Allium*, except that the plants were germinated in moist sphagnum, thoroughly rotted and washed.

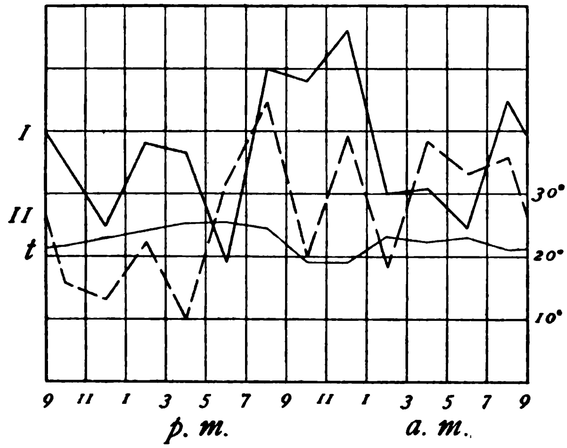

FIGURE 3. Cell-division in root of *Podophyllum*. *t*, temperature.

The results obtained from two series of root-tips cut every two hours, are shown in FIGURE 3, together with the record of the temperature of the surrounding air. These curves show more extensive minor variations than did those of *Allium*, but it is remarkable how closely similar are the curves obtained from the two plants. Even the minor variations of the main curve are always of the same nature, differing only in extent, with the single exception of the period from 4 to 6 p. m. when one curve began to ascend shortly before the other.

Underlying these minor fluctuations there are the general waves of cell-division, most clearly marked in *curve I*. These show primary maximum and minimum at midnight and 6 p. m.

respectively, and less definitely-indicated secondary maximum and and minimum about 2 p. m. and 6 a. m. respectively. In *curve II* the secondary waves are obscured by the more extensive minor variations.

In general the character of these curves derived from *Podophyllum* is quite like those from *Allium*, maximal and minimal points occurring at approximately the same hours. The most valuable evidence offered by the *Podophyllum*, however, is that such rhythms are actually present in the rate of cell-division, and that the rhythms are definite enough to be susceptible of comparison.

We may now turn to the third line of evidence upon this subject.

B. EFFECTS OF SOLUTIONS

In order to test the effects of various solutions upon the rapidity and periodicity of cell-division, onions were germinated as before in moist sand or sawdust until the roots had reached a length of 50–75 mm. The bulbs were then placed over glass tumblers where the roots were immersed in tap-water and exposed to the daylight. Some were left in tap-water and examined at intervals, others were removed after being in water a few hours, to certain solutions, and examined at intervals.

The solutions used were: (1) 4.2 per cent. glucose in tap-water, as an example of a non-electrolytic solution; (2) 2 per cent. magnesium chloride, as an isotonic electrolytic solution; (3) 2.5 per cent. peptone.

(*a*) *Water.* — We may consider first the rate of cell-division of the tips placed in tap-water and subject to the illumination of the laboratory about 2.5 m. from north and west windows. An onion with roots about 50 mm. long, grown in sand, was placed over tap-water, in such a manner that the roots were completely immersed, at 10 a. m. and beginning at 2:30 p. m. tips were removed and examined. The numbers of dividing cells at irregular intervals during the succeeding thirty-two hours are represented in *curve I*, FIGURE 4. At 2:30 p. m., when the roots had been in water for four and one-half hours, the curve is much higher than is normal for that hour. During the afternoon it falls normally and from 8 p. m. until midnight when the curve usually rises to its greatest height, this curve shows only a very slight rise which is rather an interruption in its rapid descent. After midnight there is continued descent until about noon when the curve ascends again to a maximum at 6 p. m. This maximum would have occurred normally at noon—just at the time when the ascent actually commenced. After the maximum at 6 p. m., which is the normal time for a minimal point, the curve falls again and was falling when observations ceased at 10:30 p. m.

The effect of removing the roots to water was at first a stimulation resulting in very rapid cell-division for a short time. This was followed by inhibition of cell-division and delay of its normal rhythms. The total number of dividing cells was very considerably reduced; the minimum which occurs normally about 6 a. m. was delayed until nearly noon, and the maximum which occurs normally at noon was delayed until 6 p. m. The inhibition of cell-division finally passed away partially and thirty-two hours after being placed in water (*i. e.*, at 6 p. m.) cell-division was again fairly rapid. Observations not included in the diagram were made at 10. a. m. on the two days following the last observation charted. These observations showed cell-division to be fairly active, the numbers of dividing cells being about 75–80 per cent. of the

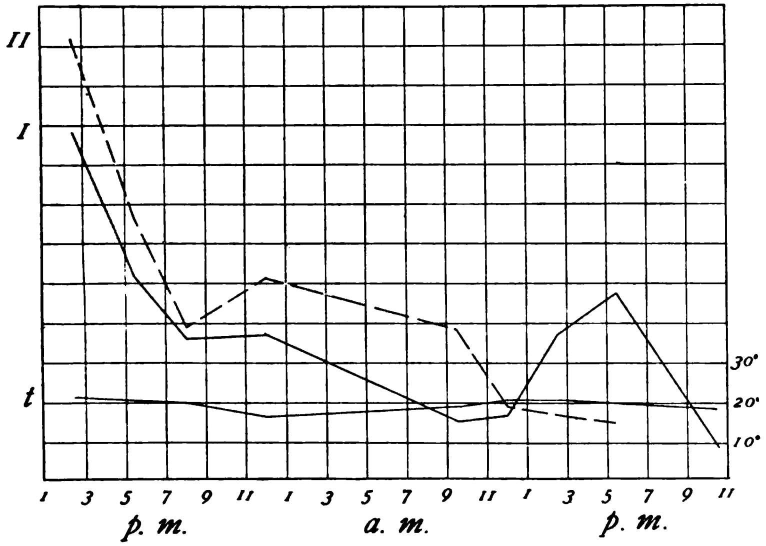

FIGURE 4. Elongation of root of *Allium* immersed in water (*I*), and in 4.2 per cent. glucose (*II*). *t*, temperature.

normal. This is important as showing that very soon (about thirty-two hours in this instance) after being placed in a new or unusual environment the process of mitosis, at first seriously deranged, tends to recover its normal course. In other words the roots very soon become adapted physiologically to their new conditions of growth.

No correlation could be observed between variations in illumination or temperature, and cell-division. In this series the temperature varied only slightly (FIGURE 4).

(*b*) *Glucose.* — As before, the roots of an onion grown in sand until they were 50–75 mm. long were placed in tap-water at 9:30 a. m. At 2:30 p. m. they were removed to a 4.2 per cent. solution of glucose in tap-water and the tips examined at irregular intervals during the succeeding 27 hours. The result of the examination is shown as *curve II*, FIGURE 4. The first part of the curve is remarkably similar to *curve I.* In one respect it is more typical, namely in the rise just before midnight, where the tips in water showed only a pause in the descent. The latter part of the curve, however, is more atypical and does not give any sign of a delayed tendency to rise as was the case with the roots placed in water. This is probably to be correlated with the greater amount of stimulation resulting from the presence of an unusual substance in solution in such quantity. No later observation was made on this bulb.

The temperature was as in *curve I*, so that it is similarly true here that the variations in temperature and illumination of the laboratory seem to have no effect upon the frequency of mitosis.

(*c*) *Magnesium chloride.* — It was found that root-tips removed from water to a solution of $MgCl_2$ isotonic with the 4.2 per cent. solution of glucose, *i. e.*, a 2 per cent. solution $MgCl_2$, were seriously affected. The cells became vacuolated and somewhat shrunken and their condition became so abnormal in a few hours that there was no cell-division whatever in progress. Consequently roots were left in the $MgCl_2$ solution for only a short time and then were replaced in water.

For example, the roots of an onion grown in sand were placed in tap-water at 9:30 a. m. At 1:30 p. m. the tap-water was replaced by a 2 per cent. solution of $MgCl_2$ in tap-water and left six hours; at 7:30 p. m. the roots were replaced in tap-water. Examination of the tips gave the results tabulated as *curve I*, FIGURE 5. At the time the roots were placed in the solution, cell-division was proceeding at about the usual rate for those tips similarly placed in water. After removal to the solution, however, cell-division decreased very rapidly. After replacing in water, cell-division recommenced and after a period of two hours we find the rate of mitosis gradually increasing until five hours after removal from the solution the rate was above the normal for roots placed in water, or about like those placed in glucose. Unfortunately the number of tips on this bulb was exhausted at this time and no further observation was possible.

(*d*) *Peptone.* — As a non-crystallizable, nutrient solution, a 25. per cent. solution of peptone in tap-water was used. As before,

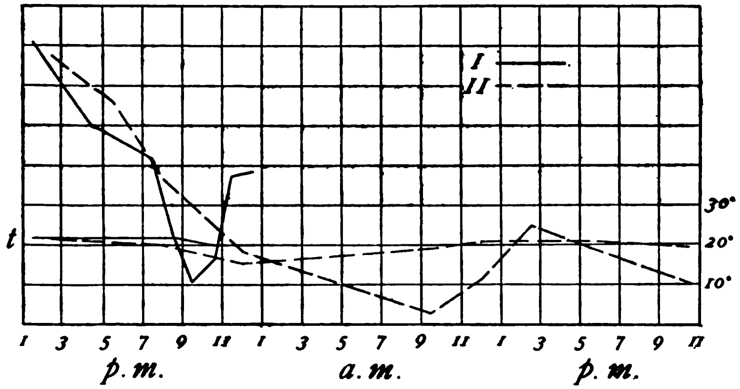

FIGURE 5. Elongation of root of *Allium* immersed in 2 per cent. MgCl$_2$ (*I*), and in 2.5 per cent. peptone (*II*). *t*, temperature.

roots were removed from sand to water at 10 a. m. At 2:30 p. m. they were transferred to the peptone solution and examined at intervals during a period of thirty hours. The rate of mitosis in these tips is shown graphically in *curve II*, FIGURE 5. In general it is very similar to the curves of tips in water and glucose, especially during its later course. In its earlier portion it lacks the pause or rise just before midnight. Cell-division almost stopped after 16–20 hours in the solution.

As already stated the general result of placing growing roots in liquids or solutions is to decrease the rate of cell-division and to delay its normal rhythm. Upon comparing the effects of various types of solutions certain tentative inferences may be drawn. The effect of a non-electrolytic solution (glucose) is not different from that of tap-water alone; in this instance the plant did not tend to recover its normal rhythm, *i. e.*, to adapt itself, as did the plant placed in water alone, although the first effect was not quite as marked.

The effect of a brief immersion in an electrolytic solution (magnesium chloride), however, was the almost complete stoppage of cell-division; recovery commenced shortly after removal to water. The effect of a solution of peptone is to cause a reduction of the rate of cell-division greater than that produced by water alone; the rhythm is not affected dissimilarly.

From the small number of observations made it is obviously impossible to make a definite statement regarding the specific effect of any of these solutions upon cell-division. The purpose of placing the roots in these solutions was not at all to test their specific effects, but to determine the effects of liquids in general upon the rate and rhythm of cell-division; rather to see whether the normal rhythm was actually a definite thing and whether it would be maintained or modified under abnormal external conditions. From this point of view the evidence from the experiments was decisive and positive. That the rhythm is a definite occurrence is sufficiently indicated by the uniform periods of increase and decrease in the rate of mitosis in all series of tips whether under normal or abnormal conditions. The result of placing the tips in liquids is to prolong the rhythm and so to delay the maximal and minimal points, although these tend to recur at the normal hour even under abnormal conditions, and to decrease the rate of cell-division. This accords with the observations of Sachs,* Wacker,† and others that the roots of land plants are shorter when grown in water — undergoing a sort of retardation of growth.

It is noteworthy that in none of the series could there be seen any direct effect of change in temperature. The variations however were slight, and it almost goes without saying that wide variations in temperature would have a very marked effect upon the rate of mitosis. Nor could there be observed any effect upon mitosis of changes in the feeble illumination of the laboratory. Normally, of course, the root is in a constant condition of darkness and it is therefore worthy of note that the rhythm in the varying illumination of the room had no definite effect upon the rate of cell-division.

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* Sachs, J. Arbeiten Bot. Inst. Würzburg, 1 : 385.

† Wacker, J. Die Beeinflussung des Wachsthums der Wurzeln durch das umgebende Medium. Jahrb. Wiss. Bot. 32 : 71–116. 1898.

Finally then, summing up in regard to periodicity of cell-division, we may say that there is a definite and regular rhythm in the root of *Allium*. Under normal conditions of growth, cell-division is most active just before midnight and just after noon and is least active about 6 a. m. and 4 p. m. There may be variations from these times within limits of about two hours.

Very little is possible in the way of comparing these results with the work of others. Famintzin,* Strasburger † and others have noted that in most algae cell-division is most rapid at night. Lewis ‡ in a very brief communication noted that cell-division in the root of the onion growing in water and exposed to the light, was most rapid about noon and slowest about 4 p. m., while in roots growing in water but in a vessel painted with lamp-black cell-division was slowest at midnight and fastest about 4 p. m. Insufficient data are given concerning the conditions under which these results were obtained to enable us to judge of the value of these observations.

5. Daily periodicity of elongation

The observations upon the elongation of the root of *Allium* were all made upon the roots of bulbs of uniform size and with approximately equal numbers of roots, *i. e.* about six. The length of the roots varied between 35 and 50 mm. at the beginning of the observation. The roots had been grown entirely in the dark, the bulbs not having been exposed to the light after germination was begun, so that no rhythmic character of elongation could be due to the direct influence of alternating illumination. The temperature in the dark room varied within narrow limits only and the temperature within the pot containing the roots must have been nearly constant. Thus the factors of varying illumination and temperature were ruled out.

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* **Famintzin, A.** Die Wirkung des Lichtes auf Algen und einige andere ihnen nahe verwandte Organismen. Jahrb. Wiss. Bot. **6**: 40. 1867.

† Strasburger, E. Zellbildung und Zelltheilung. 3 Aufl. 171. 1880.

‡ Lewis, A. C. Contributions to the knowledge of the physiology of karyokinesis. Bot. Gaz. **32**: 424–426. 1901.

The facts that the roots were of different lengths and that they showed different total amounts of elongation during the periods of observation show that the roots were not all in the same phase of the grand period of growth. This has to be taken into account constantly in comparing the different curves of growth, for some will show a general upward course, others a downward or even course, depending upon the relative portion of the grand period of growth which is represented. Thus while in the daily curves of elongation the actual maximal and minimal points coincide, their relative heights might vary somewhat.

TABLE II

ELONGATION OF THE ROOT OF ALLIUM. TOTAL ELONGATION, 24 HRS. = 16.1 MM.

Time of observation.	Elongation in one hour, in micrometer spaces.	Temperature.	Time of observation.	Elongation in one hour, in micrometer spaces.	Temperature.
9 a. m.	10.00	21.0°	9 p. m.	8.00	20.5°
10 "	8.75	20.5°	10 "	8.00	"
11 "	8.50	"	11 "	6.00	"
12 m.	10.00	"	12 n.	7.00	"
1 p. m.	10.00	"	1 a. m.	8.00	"
2 "	9.00	"	2 "	8.00	20.0°
3 "	9.00	"	3 "	7.00	"
4 "	9.50	"	4 "	7.00	"
5 "	8.75	"	5 "	8.00	"
6 "	8.75	"	6 "	9.00	"
7 "	8.75	"	7 "	8.00	"
8 "	9.00	"	8 "	9.00	"

(*a*) *Typical observation.* — We may take as an example a record of the elongation of the root showing the hourly elongation in micrometer spaces (Leitz horizontal microscope) as given in TABLE II. This is expressed as a curve in FIGURE 6, *curve I*, where the observed elongation is multiplied by four to bring out better the form of the curve.

There are seen to be apparently three maxima and three minima in the rate of elongation. The most extensive maximum (primary maximum) has its apex at 4 p. m. The primary minimum has its apex at 10 p. m. Secondary maxima occur at 3 a. m.

and 7 a. m. and secondary minima at 5 a. m. and 1 p. m. These secondary maxima and minima are relatively much less marked than the primary waves and, occurring as they do so near together, it is likely that they are to be considered properly as minor fluctuations on a broader maximal wave reaching its height (secondary maximum) about 7 a. m.; the secondary minimum would then be found about noon. The other irregularities in the curve are quite slight.

The observations on some of the roots were made only bi-hourly, therefore for purposes of comparison later, we may write this curve as if observations had been made bi-hourly, as *curve I*, FIGURE 7. The result, of course, is to reduce the irregularities of the curve and slightly to alter the times of the apices of the principal waves, *e. g.* the primary maximum now appears at 5 p. m. instead of 4 p. m., the primary minimum at 11 p. m. instead of 10 p. m.

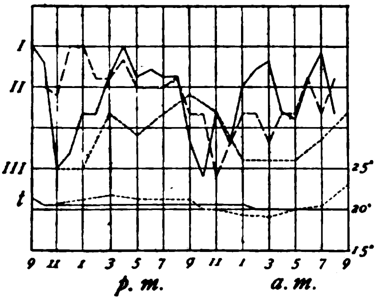

FIGURE 6. Elongation of root of *Allium*. *t*, temperature.

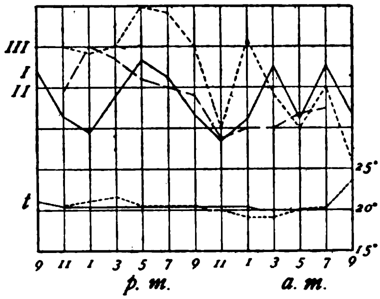

FIGURE 7. Elongation of root of *Allium*. *t*, temperature.

(*b*) *Comparison of other observations.* — *Curve III*, FIGURE 7, illustrates the rate of elongation of a root observed bi-hourly. The general appearance of this curve is somewhat modified from the fact that it was taken after the maximum of the grand period of growth had been passed and consequently the rate of elongation is lower at the end than at the beginning of the observation. The actual hours of maxima and minima are, however, almost exactly as in the curve just described. That is, there are primary maximal and minimal points at 5 p. m. and 11 p. m. respectively, and secondary maximal and minimal points at 7 a. m. and 1 p. m The temperature varied more during this observation than during the preceding one, but still no correlation is observable between variations in temperature and rate of elongation.

Another record, *curve II*, FIGURES 6 and 7, was made at the same time as *curve I* and under identical conditions. The points of dissimilarity between the two are of degree rather than of kind. There is just the same pronounced minimum at 11 p. m. The primary maximum however occurs somewhat earlier, that is at 1 p. m. The secondary maximum occurs at the usual hour. The secondary minimum about noon is not very clearly marked but is indicated at 11 a. m. On the whole the secondary waves are all less definite than in the curves previously described.

Finally, another record made under conditions identical with those of *curve III*, FIGURE 7, must be considered. This record is illustrated as *curve III*, FIGURE 6. This is the only root observed during the ascent of the grand period of growth and most of its very evident peculiarities may be explained in connection with this fact. The rate of elongation reaches its primary maximum at 9 p. m. Another maximum is marked definitely at 3 p. m. and the rate was increasing again steadily when the observation ended at 9 a. m., as if to mark another maximum. A very extensive minimum occurs between 1 and 5 a. m., and at the beginning of the observation a minimal period extends from 9 a. m. to 1 p. m. The features of the curve are all remarkably regular and well marked. The total amount of elongation during the 24 hours was only 13.5 mm. There is no correlation between the rate of elongation and the comparatively slight variations in temperature.

The principal peculiarities of this record are due to the appearance of the primary maximum and minimum about five hours later than normally and to the absence of the secondary waves in the early morning. A possible explanation of these peculiarities may be the following. From the comparative levels of the beginning and end of the curve and from the small amount of elongation of the root, we are evidently concerned here with a root which has not yet reached the maximum of its grand period of growth. Such a young root is growing with a greater vigor, has a greater momentum so to speak, and as a consequence is not affected by stimuli (external or internal) which would affect roots growing with less potential, such for instance as are on the descent from the maximum of the grand period. Ordinary stimuli would produce either a delayed reaction or none at all. Therefore the daily maximal and minimal periods are delayed and the stimuli usually producing the secondary waves are inoperative.

Summarizing then in regard to elongation we may say that there is a daily rhythm of elongation of the root of *Allium* which occurs in the absence of variation in illumination and independently of slight variations in temperature: this rhythm must be the result of internal factors. The daily rhythm is such that elongation is most rapid about 4 or 5 p.m. and slowest about 11 p. m. Besides these primary waves there are secondary points, the secondary maximum occurring about 7 a. m. and the secondary minimum about noon.

It will be well to compare, at this point, these results on *Allium* with those derived from the study of other subterranean organs. As mentioned in the introduction to this paper,* the only records are those of Strehl and MacMillan. Strehl found that there was a single maximal and minimal wave in the rate of elongation every twenty-four hours, the rate being highest about midnight and lowest about noon. His curves, which represent observations extending over several days, show admirably the varying appearance of the daily curve depending on the phase of the grand period which it represents. Strehl's observations were made upon the roots of *Lupinus*, and the conditions under which they were growing were far from normal; *i. e.*, the roots were growing in water and were contained in glass placed only 1.5 m. from a west window where they would be subject to moderately strong illumination.

In MacMillan's observations upon the growth-periodicity of the potato-tuber, the plants were under normal conditions of growth and the results are entitled to more weight. Unfortunately, as he himself states, his observations were of a fragmentary nature and were to be considered rather as a preliminary report. MacMillan concluded that the rate of increase in diameter of the potato-tuber occurred rhythmically, with one, two, or perhaps more maxima in twenty-four hours. He believes that the tuber has an independent rhythm of its own in addition to a rhythm induced by that of the stem and other aërial parts, and offers some tentative explanations of both of these. The fact that here interests us particularly is that there is frequently a double maximum in the rate of growth during the twenty-four hour period. Thus far there is agreement with the root of *Allium ;* how much farther this agreement extends can not be stated, for MacMillan does not mention any hours at which these maxima occur.

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* See page 530.

We may also compare briefly at this point, the rhythm of elongation of the aërial parts. Observations upon *Allium* have been made by Stebler* on the elongation of the leaf. Stebler found that the maximum of growth coincides with the period of greatest light intensity (12–4 p. m.), growth being slower during the night, the minimum occurring between 12 and 4 a. m. His curves show this single wave very definitely. Many others working on other plants have found similarly a single daily wave of growth, although the actual periods of maximum and minimum do not always correspond by any means. Thus, for example, Sachs † found the elongation in *Dahlia* to be most rapid in the early morning (6–9 a. m.) and the slowest in the evening, (3–6 p. m).; Prantl ‡ in *Cucurbita* found the maximum elongation to occur about 3 p. m. (12–6 p. m.) and the minimum from 3 to 6 a. m.; and, to complete the possibilities, MacDougal § found that in the leaf of *Hyacinthus* the maximum of elongation occurs between midnight and 4 a. m. and the minimum about noon. The only uniformity here is the single maximum and minimum each day.

Godlewski ‖ at first observed only a single wave of elongation in the epicotyl of *Phaseolus*, but later he found that there were definitely two maximal and two minimal periods during twenty-four hours. The minima occurred morning and evening and the maxima day and night; the relative intensities of the maxima and minima were inconstant even in the same plant. This is apparently the only recorded instance of a double daily wave of growth in an aërial part, of such a nature as is found in the root.

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* Stebler, F. G. Untersuchungen über das Blattwachsthum. Jahrb. Wiss. Bot. 11: 47–123. 1878.

† Sachs, J. Arbeiten Bot. Inst. Würzburg. 1: —.

‡ Prantl, K. Arbeiten Bot. Inst. Würzburg, 2: —.

§ MacDougal, D. T. Text-book of plant physiology, 295. New York. 1901.

‖ Godlewski, E. Studien über das Wachsthum der Pflanzen. Abh. Krakauer Akad. Wiss. Math-Naturw. Classe, 23: 1–157. (Abstract by Rothert, Bot. Centralblatt, 55: 34-40. 1893.)

6. Relation between cell-division and elongation

The actual relation in time between cell-division and elongation can be seen most easily by reference to FIGURE 8, where there are composite curves of all my records of normal cell-division and elongation reduced to similar proportions. It is at once evident that the rhythms agree in time but always occur in opposite directions, *i. e.* when elongation is at a maximum cell-division is at a minimum and vice versa. The primary maximum of cell-division corresponds perfectly with the primary minimum of elongation at 11 p. m. The primary maximum of elongation corresponds with the secondary minimum of cell-division about 5 p. m., while the primary minimum of cell-division occurs at the time of the secondary maximum of elongation at 5 a. m. In general, throughout, the curves have opposite directions. The only real exception occurs between 3 and 7 a. m. when, as already noted, the decreasing rate of elongation can hardly be considered a constant

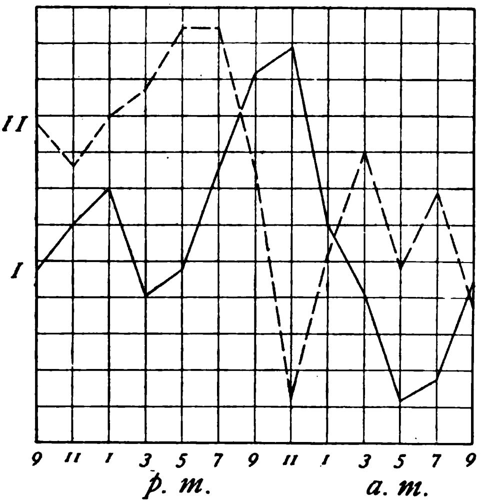

FIGURE 8. Composite curves of cell-division (*I*) and elongation (*II*).

feature; it is quite likely that the rate of elongation increases uniformly from 11 p. m. until 7 a. m.

These time relations, however, do not lead to the understanding of any causal relation more definite than that expressed by Ward,* that the energy of the cell is not sufficient to enable it to continue its growth and at the same time form new cellular elements; therefore when the cell is dividing and the new cell-wall forming, etc., the energy of the cell is diverted from its other growth-processes and elongation is arrested. Rhythmic activity resulting from the uniform action of stimuli or forces is quite universal and it may be that here in the root where external conditions are practically uniform, we are dealing with a rhythm which is not related directly to the external environment, but which results from the activity of the root itself, *i. e.*, is internal in its origin. There can be no doubt that the rhythm in the stem is to a greater or less extent an induced one, and it is difficult to believe that the pronounced rhythm of the stem is without influence upon the root; yet in the roots of these bulbs without growing aerial organs, definite rhythms are established. We should know whether this rhythm of the root is maintained unchanged after the development of the leaves with their marked daily rhythm. With our present limited information we are hardly justified in making assumptions as to what are the causal relations between cell-division and elongation, both to each other and to the other vital activities of the plant.

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* Ward, H. M., *loc. cit.*

COLUMBIA UNIVERSITY,
June 1, 1904.

The Publications of the Department of Botany, Columbia University, consist of Memoirs in quarto and Contributions in octavo.

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[*] Nos. 157 and 158, with the set of nine papers by Mr. Bicknell on *Sisyrinchium*, can be had for one dollar and fifty cents.

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THE COMPARATIVE EMBRYOLOGY OF THE CUCURBITACEAE

BY

JOSEPH EDWARD KIRKWOOD

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE
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BY JOSEPH EDWARD KIRKWOOD.

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PART I. INTRODUCTION

This work was begun at Princeton in the year 1898 while the writer was special fellow in biology in Princeton University. *Sicyos angulata* L., which was found growing in that vicinity, seemed to be a favorable object for study and some of the inflorescences were accordingly gathered and a brief examination made of the development of the gynoecium and the embryo-sac.

Though the results of this study were somewhat meager, it was nevertheless thought advisable to continue the work and extend the investigation to other members of the Cucurbitaceae. This was undertaken at the suggestion of Professor F. E. Lloyd, and carried on during the years 1899 and 1900 and the summer of 1902 at the New York Botanical Garden.

The characters of certain members of this large and interesting family suggested an attractive problem in the comparative organogeny of the flowers. In this work special attention has been given to the organogeny of the gynoecium. Some evidence has been collected as to the nature of the inferior ovary in this family and a discussion of the literature on this point will be presented later (Part III).

Besides the morphology of the flower there are interesting facts in connection with the development of the embryo-sac and associated structures which deserve attention. But the morphological problems involved in this study are of less importance, in the writer's estimation, than are those of a physiological character. The structure of the embryo, the growth and character of the endosperm, the distribution of nutritive materials in the ovule and the placenta, all are matters of importance; an understanding of the physiological conditions obtaining in the ovule is no small aid to the interpretation of various structures and phenomena, and this conception is becoming more and more the dominant idea in modern investigations. "An account of organic evolution, in its more special aspects, must be essentially an account of the interactions of structures and functions," are the words of Herbert Spencer, quoted and emphasized by Goebel in his *Organography*. The fruitfulness of this thought is brought more strikingly to our attention when we consider the trend of later researches and the character of their results.

Treub[82] in his memorable work, *Notes sur l' embryogénie de quelques Orchidées*, emphasized the thought that the manner in which the embryos absorb the plastic substances certainly deserves to attract attention, and further, that the problem should be elucidated by embryological researches. While, as has already been said, this view has dominated much of the embryological investigation of more recent years, the importance of the problem was recognized before the publication of the work just cited, as Treub himself points out. Hofmeister[41] (1849) saw and described antipodal cells and attributed to them the function of elaborating food for the young embryo, although in a later work[42] (1867) he says that the antipodals are meaningless in the development of the embryo and that after fertilization they develop no further but are themselves soon dissolved. Twenty-five years later, however, Westermaier[88] takes up the subject of the antipodals and in conclusion says: "In the development of the so-called antipodal cells in the embryo-sac of angiosperms, contrary to former views, one has to deal with an anatomical-physiological apparatus and not with a useless rudimentary structure which would be incomprehensible except from the standpoint of comparative morphology." The grounds upon which a physiological meaning is given to the cases in question are particularly:

(1) In the specific position of these cells in the embryo-sac and in the quality of the contents of the cells themselves.

(2) In their anatomical relations and the character (cuticularized) of certain membranes in the ovule.

(3) The manner of starch distribution in the inner part of the nucellus.

In 1896 he refers[89] to the work on *Nigella* (1890) in which he ascribed to the polar nuclei or later the endosperm nucleus the function of conserving the antipodals in spite of the lengthening of the embryo-sac and of fixing the said apparatus in closer proximity to the micropyle in the interest of the first embryonic development. He concludes by saying: "The antipodals are a nourishing apparatus for the embryo in the foetal developmental period."

We find this view strengthened by the results of the work of Campbell[11] on *Sparganium* and Chamberlain[16] on *Aster*, in which cases the antipodals seem to have an important nutritive function. Merrell,[58] however, regards the antipodals of *Silphium* as performing the function of conduction of nutritive substances, and Mlle. Goldflus[31] interprets the antipodals in several genera of the Compositae as haustoria, from the fact that they elongate and appear to be associated with certain conducting tissue at the base of the ovule. Evidence on this point has also been found in *Callipeltis* and *Galium*.[53] To this view, moreover, we were directed by the form and structure of these cells in another family of plants (Liliaceae) investigated by Ikeda,[44] who finds similar anatomical features. The cells themselves show the phenomenon of chromatin aggregation, indicating metabolic activity, and these stand in relation to elongated cells of the nucellus which extend to the chalaza, forming a "conducting passage." At the same time certain features in the distribution of starch and soluble carbohydrates, dextrin, etc., indicate that the center of activity for the elaboration of food for the embryo is the antipodals.

At this point attention may be called in passing to the more recent investigations which have shown certain peculiarities in the part which the endosperm plays in the nutrition of the embryo. Balicka-Iwanowska[4] in studying the embryo-sac of a number of sympetalous genera found both micropylar and chalazal haustoria of endospermic origin. In a recent contribution, Johnson[47] has pointed out the digestive function of the endosperm in the perisperm-bearing seeds of certain Piperaceae.

Attention has repeatedly been called to the function of the suspensor as a means of conducting nutritive substances. In 1858 Hofmeister[43] stated that an unusually long and well developed suspensor is accompanied by weakly developed or almost entirely suppressed endosperm in *Tropaeolum*, *Trapa*, the Geraniaceae and the Caryophyllaceae. Treub[82] concluded that the suspensor performed a physiological function in the transmission of nutritive substances, and that the want of a suspensor was correlated with the character of the outer cell-walls of the embryo. He says in substance that the embryos are nourished by means of strongly developed suspensors; while the outer cell-walls of the embryos are strongly cuticularized, the suspensors of these on the contrary consist of pure cellulose (*Herminium Monorchis*). Embryos with rudimentary suspensors or none at all, had a thin and permeable cuticle. In the Leguminosae, Guignard[35] found cases in which embryos with rudimentary suspensors or none at all were at a very early stage completely surrounded by endosperm. The development of the complex coenocytic suspensor of *Orobus* is accompanied by the scanty formation of endosperm, and the author suggests that it may find its chief function in the nutrition of the embryo.

The work of Koorders[51] furnishes us with a unique case in which the suspensor acts as a means of transmission of nutritive materials which it obtains through certain of the endosperm cells that attach themselves to the suspensor and elongate into tubular bodies, acting as haustoria. In this case the embryo is cuticularized over its outer surface until the cotylendons are differentiated, whose peripheral cells possess thin and permeable walls.

In the Galieae Lloyd[53] reports cases analogous to that found by Koorders[51] in *Tectonia*. In *Vaillantia* and *Galium* some of the cells of the suspensor elongate laterally to form haustoria which penetrate the surrounding endosperm to a considerable depth, seemingly, as the author suggests, increasing the surface for absorption, and thus providing for a rapid growth of the young embryo.

In some of the later researches the behavior of the pollen-tube has been carefully considered. Longo[54] finds that in *Cucurbita Pepo* it follows a definite conducting tissue from the stigma to the embryo-sac. In the apical region of the nucellus the tube expands and sends branches into the surrounding tissues, the branching being correlated with the distribution of starch in those parts. It is the thought of Longo that the growth of the pollen-tube along the conducting tissue is an expression of chemotropism, in which he is in accord with the views of Molisch. In different species of the same genus Longo shows that the pollen-tube may pass through the conducting tissues or on their surfaces in ovarian spaces, the stimulus being in the nature of a secretion. Lloyd found in *Diodia* and *Richardsonia* that the pollen-tube was endotropic and ectotropic in different parts of the same ovary. He concludes that the behavior of the pollen-tube, whether ectotropic or endotropic, is a purely physiological character, and of no phylogenetic significance as interpreted by Treub and Nawaschin.*

The growth of the pollen-tube toward the ovule and its ultimate arrival at the embryo-sac indicate either some mechanical relations (Miyoshi)[62] or the differential distribution of the stimulant by which it may be directed chemotropically. That the source of this stimulant is either the oösphere or the synergids there is some reason to believe, and this view has already been advanced by Lloyd.[53]

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*See Lloyd: The pollen-tube in the Cucurbitaceae and Rubiaceae. Torreya, 4: 86–91. June, 1904.

Whether we are to regard the synergids as a center for the distribution of a stimulant or as a means of transmission of the generative nuclei of the pollen-tube is difficult to determine. Indeed they may perform both of these functions. That the physiological properties of the different embryo-sac cells are variable there is abundant evidence. Dodel[20] describes the fertilization of synergids in *Iris Sibirica*. Embryos are occasionally derived from antipodals (Tretjakow[84]), and the fertilization of the polar nuclei is now known to occur in many plants.

Investigations relative to the embryo-sac and associated structures in the Sympetalae have been particularly abundant in recent years. We have the works of Chamberlain,[16] Merrell,[58] Goldflus[31] and Juel[46] on the Compositae; of Balicka-Iwanowska[4] on the Scrophulariaceae, Plantaginaceae, Campanulaceae and Dipsaceae; of Guignard[36] on the Solanaceae; of Lloyd[53] on the Rubiaceae; of Billings[7] on the Caprifoliaceae, Globulariaceae, Goodeniaceae, Hydrophyllaceae and Primulaceae; and numerous others. Very little, however, has been done upon the Cucurbitaceae.

The first work of any importance which touches the embryology of the Cucurbitaceae was that of Brongniart[8] in 1826. In this he has figured better than he has described the embryo-sac of *Pepo macrocarpus* and *Momordica Elaterium*. In the former the anatomy of the ovule corresponds to the general type and is essentially correct. While most of this work has to do with the process of fertilization and will be referred to later, it is interesting to note that in *Pepo* the peculiar form of the endosperm in its coecum-like prolongation towards the chalaza is figured with approximate accuracy, and the action of endosperm upon the nucellus is also shown in *Momordica*.

Mirbel[60] in 1829 describes the structure of the ovule and embryo-sac in *Cucumis Anguria* and *C. leucantha*. He points out the fact that the young ovules are at first mere protuberances, and clearly shows that the relations of the micropyle and chalaza are maintained during the turning of an anatropous ovule and that the development of the raphe brings it about that the hilum is removed from the chalaza and its position near the micropyle is attained. The chalaza is recognized as a center for the distribution of nutritive substances to the nucellus and the integuments. In *C. leucantha* he figures the endosperm in an advanced stage as occupying about half of a cavity in the nucellus and in form an ovoid mass with a tube-like prolongation at its lower end. The embryo is represented at this stage in about its proper size and appearance as a narrowly pyriform mass and of about one sixth the length of the endosperm.

In 1842 Amici * studied the process of fertilization and development in *Cucurbita Pepo*, but his work was faulty, as Schleiden later points out. Amici failed to recognize an embryo-sac in the unfertilized ovule, or prior to the opening of the flower. He thought he saw and accordingly described a canal extending through the apex of the nucellus, through which the pollen-tube passed in the process of fertilization. In the growth and development of the endosperm essentially the same features are represented as were shown by Mirbel in the case of *Cucumis leucantha*, and in this respect he is correct. In his figures his representations of the form and structure of the ovule are in the main correct, but he failed to recognize the embryo and to interpret correctly the structures surrounding it. His observations, however, upon the rate of embryo-sac development after fertilization are worth noting as being the first record of such growth. He shows that the enlargement of the embryo-sac was apparent during the first day after fertilization. When the fruit is one and one half inches thick the coecum-like prolongation of the embryo-sac has elongated to about one fourth the length of the nucellus. In a fruit four inches in diameter, he shows, this tube has practically reached to the chalaza.

Schleiden[74] in 1844 expresses surprise that no one in the company of botanists to whose attention Amici's paper came was able to detect the errors which it contained, and declared that Amici had no knowledge of the ovule in general nor of the Cucurbitaceae in particular. He declares that Amici had taken the inner integument for the nucellus and the nucellus for the embryo-sac. Schleiden contends that the embryo-sac is present before the opening of the flower, that there is no canal in the apex of the nucellus, and states that he, himself, has traced the pollen-tube in its course in *Pepo*, *Melo*, *Cucumis*, *Lagenaria* and *Momordica*, and especially in *Momordica* has seen the male generative nuclei emerge from the pollen-tube.

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* See Facchini.[22]

In the following year Facchini[23] came to the defense of Amici, stating the nine propositions which that author published, along with his plates. The effort, however, to vindicate Amici was not very successful.

In the same year (1845) Schleiden[75] returned to the attack and gave us the first account of the embryo-sac before fertilization in any of the Cucurbitaceae. In *Cucurbita Pepo* he figures an ovule with its parts correctly differentiated and states that the small embryo-sac is present before the opening of the flower, and that it has only slightly enlarged at the time of the entrance of the pollen-tube. He says further: "It is easy to observe the pollen-tube in its course from the stigma through the conducting tissue. At the time when the flower wilts and falls off, the tubes have reached the ovules, in some cases at least. The ovary at this time is about 21 mm. long and 18 mm. in diameter. When the ovary has become 35 mm. long and 22 mm. in diameter the ovule is 4 mm. long, 2 mm. broad and 1 mm. thick. When the pollen-tube has reached the apex of the nucellus the latter has partly broken down: the pollen-tube quickly runs through its length, bulges out in it and fills it with a starchy substance so that it is quite dense. The pollen-tube and the embryo-sac seem to be fused together." The tip of the nucellus, he further states, becomes disorganized as the pollen-tube expands in it, and immediately afterwards the extension of the embryo-sac toward the chalaza begins. When the ovary has reached the length of fifty millimeters the oöspore becomes visibly cellular in structure.

Hofmeister[41] in 1849 describes certain features of *Cucurbita*, *Sicyos*, and *Ecballium*. He points out the fact that in these cases the embryo-sac before fertilization is very small compared with the size of the nucellus, that in each case it lies directly under the apex of the nucellus, which has a central row of cells with transparent contents. This condition probably led Amici to the view that the nucellus was traversed by a canal in its apical region. The main points which were contributed from Hofmeister's researches may be summed up as follows: Shortly before the opening of the flower two nuclei appear at each end of the embryo-sac. Germinal nuclei arise from the micropylar cells with some exceptions (probably polar nuclei). The antipodals form no walls about themselves and their life is usually short. The oösphere is at first conical but later becomes elongated. The pollen-tube finds the micropyle while the flower is still fresh, penetrates the apex of the nucellus, and while surrounded with this tissue shows (upon treatment with potash) a wall transversely striated. The pollen-tube lies against the embryo-sac and does not effect an entrance for about forty-eight hours, more or less. During this time the ovule retains its dimensions. Fertilization takes place suddenly, the embryo-sac increases from four to five times in length and twice in breadth. The oöspore divides once transversely and the distal cell becomes the proembryo. The proembryo divides longitudinally forming two cells (*Ecballium*). A layer of free nuclei lines the embryo-sac and these form walls about themselves; a second layer is then formed, followed by a third, etc., until the embryo-sac is filled. It thickly surrounds the conical embryo, which must in turn replace it in its progress of development to the ripe seed. When the embryo is a conical mass of cells the endosperm occupies about one sixth of the space of the nucellus. Later stages show important features. Endosperm rapidly replaces the tissue of perisperm, especially about midway between micropyle and chalaza. The young embryo, from which the suspensor has already disappeared, soon shows radicle and cotyledons. The cotyledons grow very rapidly and replace the endosperm as rapidly as the latter did the perisperm. In *Ecballium* the rapidly developing endosperm performs the work of digestion. In *Cucurbita* he states that the endosperm fills the embryo-sac later than in *Ecballium*. In *Sicyos* the oösphere appears elongated, and there are numerous antipodal cells. Hofmeister thought that the ovules in all the Cucurbitaceae develop in about the same way as in *Ecballium*. His results are not entirely in accord with those of Schleiden, especially in the matter of the phenomena accompanying fertilization. But on the whole the work of Hofmeister is a distinct advance over anything that had so far been done. From the study of the material at the present time, however, it would be impossible to confirm in all points the account which he gave to science in the classic work just cited. Considering the conditions under which Hofmeister worked, we are the more surprised that the work was as accurately done as it was. There were many points difficult of demonstration which have been clearly set forth in his work, which we with all our knowledge of technique have not been able to change materially. Our knowledge of the processes of spore development, fecundation, and embryology in the Cucurbitaceae remain to-day substantially as Hofmeister left them over fifty years ago. His work on this family was not in all points correct, as will appear when we come to the discussion of some of the particular types of which he treats.

While attention has been given to the structure of the ovule and the phenomena of embryonic growth, practically nothing has been contributed in regard to the earlier stages of development, and what has been described of the later phases has been of a very brief character with reference to a few particular forms. In some forms the development of the microspores has received attention, but nothing has been done on the character of the nuclear divisions of the spore-mother-cells. Some observations have been made upon the development of the ovule and upon the placentation, and some upon the general organogeny of pistillate and staminate flowers, more particularly the former. It still appears to be an open question as to the morphological nature of the androecium and little or nothing has been done to compare the earlier stages of development in widely differing representatives of this family. It shall be the aim of this paper to follow, as closely as the writer has been able to observe, the process of development of the essential organs in the pistillate flowers, to describe the anatomy of those organs especially with reference to the work of fecundation and seminal development, and the behavior of the pollen-tube. It is hoped that light may be thrown upon the morphology of the floral organs and upon the problems of nutrition.

The methods used were those most commonly employed in embryological researches. The material was fixed by two methods, viz., the use of Flemming's stronger solution, and of an acetic-acid-alcohol mixture in which the ingredients were in the following proportions: glacial acetic acid 1 part, 70 per cent. alcohol 2 parts. The latter proved to be more satisfactory in some cases, where the presence of oil in the embryo-sac and vicinity rendered the use of osmic acid mixture inconvenient. In the use of both media, however, good fixations generally resulted.

In this connection the writer desires to express his appreciation of the kindness of those who have in various ways assisted in this work: to Professor F. E. Lloyd, at whose instance this problem was undertaken and whose helpful suggestions have from time to time been very acceptable; to Professor N. L. Britton and Dr. D. T. MacDougal, through whose courtesy the author was given the privileges of the laboratories and plantations of the New York Botanical Garden during the summer of 1902; also to Hon. William Fawcett, Director of the Hope Gardens at Kingston, Jamaica, who so kindly furnished the material of *Fevillea*, to Dr. David Griffiths for the material of *Apodanthera*, and to Messrs. Peter Henderson & Co. for the use of plants on their trial grounds on Long Island.

PART II. DESCRIPTIVE

The Cucurbitaceae constitute a family of plants whose systematic position and relationship have been much disputed. Naudin and also Bentham and Hooker[6] have considered them more nearly allied to the Passifloraceae. Baillon[3] has regarded them as related to the Loasaceae and Begoniaceae. They are usually regarded, however, in accordance with Braun's view, as near relatives of the Campanulaceae, from which they are separated chiefly by the character of the androecium and the lack of latex vessels.

Eighty-five genera, of which by far the larger number belong to the Eastern Hemisphere, constitute this family. They are mostly natives of the tropical or subtropical latitudes, a few only being natives of the temperate zones. For this reason the obtaining of material for this study has been beset with difficulties. Material suitably prepared was difficult to obtain from the native habitats of some of the desirable forms, and those cultivated at New York City and Syracuse, N. Y. were in many cases unproductive. The eighty-five genera fall naturally into five tribes recognized by Engler and Prantl.[64] Of the eight tribes into which the family was divided by Cogniaux[20] four have been reduced very properly, it would seem, to subordinate rank. The tribes as they shall be considered here are the Fevilleae, Melothrieae, Cucurbiteae, Sicyoideae and Cyclanthereae.

The forms which have been studied in connection with this work comprise seventeen species selected partly because they were the best available, but at the same time an effort was made to obtain forms which would be as typical as possible of different tribes and representative of the most widely differing forms. They are divided among the different tribes as follows: in the Fevilleae, *Fevillea cordifolia* L.; in the Melothrieae, *Melothria pendula* L., *Apodanthera undulata* Asa Gray; in the Cucurbiteae, *Momordica Charantia* L., *Luffa acutangula* (L.) Roxb., *Citrullus Citrullus* (L.) Karst. (*Citrullus vulgaris* Schrad.), *Cucumis myriocarpus* Naud., *Bryonopsis laciniosa erythrocarpa* Naud., *Benincasa hispida* (Thunb.) Cogn., *Lagenaria Lagenaria* (L.) Lyons (*Lagenaria vulgaris* Sér.), *Trichosanthes Anguina* L., *Cucurbita Pepo* L.; in the Sicyoideae, *Coccinia cordifolia* (L.) Cogn., *Micrampelis lobata* (Michx.) Greene, *Sicyos angulata* L.; in the Cyclanthereae, *Cyclanthera explodens* Naud.

ORGANOGENY OF THE GYNOECIUM

The form, size and structure of the ovary varies much in the different genera and species. The ovary, in all cases inferior, may contain one seed, as in *Sicyos*, or many, as in *Cucurbita*, distributed in various ways presently to be described.

As early as 1682 Nehemiah Grew[39] in his Anatomy of Plants described the structure of the ovary and the manner of placentation in *Cucumis sativus*. He says, "The middle parenchyma is divided into three columns which stand triangularly, having each of them a triangular figure." "These columns are, as it were, beds on which the seeds grow." He found the ovary divided into six triangles and each triangle to contain three "ovals."

Gaertner[25] more than one hundred years later described and figured the more obvious structural features of the seeds and ovaries of *Sicyos*, *Bryonia*, *Momordica*, *Cucurbita*, *Cucumis* and *Lagenaria*. His figures, though not very clear in all points, show very well the divisions of ovary and the parietal attachment of the seeds in *Cucumis* and *Cucurbita*.

In 1815 Mirbel,[59] in describing the form of fruit known as a pepo refers to the structure of the ovary of the Cucurbitaceae. His reference is particularly to *Cucurbita* and *Cucumis*, and he states that the ovary is divided into many locules by radiating placentae, the lobes of which are bordered by nerves which bear the ovules, the latter being borne in two ranks on each lobe. In some cases, he points out, locules are divided each by a pulpy wall.

Brongniart[8] (1826) described the anatomy of the ovary of *Cucurbita Pepo* with special reference, however, to the conducting tissue. He regarded the ovules as being borne on the edges of the carpels, and in general as representing the teeth of the leaves.

Coming down to the more recent work of Eichler[21] (1875) we find a discussion of the relations of the parts of the flowers of both kinds. The ovary of *Cucurbita* is divided into three parts, or four or five parts, representing as many carpels. The edges of these carpels are turned inward, meet at the center of the ovary and are flexed back toward the outside again lying one beside another, and these reflexed margins form the placentae. The stigma which surmounts the ovary has lobes equal in number to the carpels and standing opposite to them. He represents the placental folds as being separated by a false commissure, evidently formed by the reflexed laminae of the carpellary leaves.

Ecballium agreste and *Bryonia dioecia* show a lesser development of the carpellary margins so that the commisural partitions are not so complete. The pistillate flowers of *Sicyos* are often on the tetramerous plan, probably by reduction from the pentamerous form (as in certain of the Plantaginaceae), by abortion of the calyx-lobe next the axis and the fusion of the two nearest corolla-lobes. From the fact that the stigma is divided into from three to five lobes, he regards the ovary as composed of the same number of carpels, but is uncertain whether to regard the lobes as representing the middle of the carpels or their borders.

Müller[64] (1889) refers largely to Eichler's work in discussing the floral structures. He points out the principal features in the structure of the ovary, and shows that the three principal partitions in the ovary of most of the Cucurbitaceae are the infolded margins of the carpels which grow back toward the wall of the ovary again after reaching the center, thus forming the placenta. This is shown in pistillodia, which show different stages in this process of development. He considers the original ovary to have had five locules, but the prevailing type has three. Each carpel is surmounted by a two-lobed stigma, but these lobes fuse often with the adjacent lobes of other carpels and thus the true stigmatic lobes stand opposite the partitions and not opposite the carpels.

The observations upon the development of the gynoecium of the Cucurbitaceae, as about to be described, have been carefully made by means of microtome sections of the growing tips of the flowering shoot. The serial sections prepared have afforded a means of comparison of the different stages of growth quite satisfactory.

Fevilleae

The apex of the stem of *Fevillea* presents a dome-like form and in longitudinal section shows its epidermal and subepidermal cells in regular series lying in "confocal parabola" as Strasburger[79] describes for *Polygonum divaricatum*. The regularity in the arrangement of the cells is maintained to three or four layers below the epidermis. Slightly below the apex of the stem in the axil of a leaf-rudiment may be found the primordia of the young flowers. A blunt outgrowth may here be seen, which in the progress of its growth soon loses all trace of the confocal arrangement of its cells, and by numerous divisions, longitudinal with reference to the axis of the flower, becomes flattened at the apex and broadens out like the base of a cone. Around the border of this body, in a slightly later stage, five slight elevations may be detected which become quite distinct before any other organs are differentiated. Figure *5* (Pl. I) shows the young floral rudiment, with two of the five young calyx-lobes, bent sharply over the flattened end.

Goebel[29] describes the development of the gynoecium in *Epiphyllum truncatum* which, he declares, is in the fundamental points the same process of development as that which is to be observed in all inferior ovaries. In *Epiphyllum* the calyx and corolla arise in spiral order but before they are all laid down the flattened end of the axis shows a crater-like deepening, from the borders of which the carpels spring and grow up to form the style. The placentae are developed as swellings where the edges of the carpels meet. In *Fevillea* the case is practically the same. After the differentiation of the five outer lobes, there arise on the border of the disc-like area, which they surround, five other lobes alternate with the first and subsequently five other elevations may be noticed opposite the calyx-lobes. These represent the staminodia and for a time they resemble the young corolla-lobes. Soon after these lobes become distinctly visible, the deepening of the central area takes place and the carpels appear as slight elevations on the sides of the concavity (*fig. 6*). The number of carpels constituting the gynoecium of *Fevillea* is three; the number of the calyx and corolla-lobes is five: hence a carpel may sometimes be opposite a lobe of the corolla sometimes on a radius between two. Figure *6* shows the origin of one of the carpels as seen in a longitudinal section of a flower in the stage of development just referred to. The carpel in this case appears to originate in a slight elevation of cells between the corolla-lobe and the bottom of the depression. As growth proceeds the cavity becomes deeper, the carpels and the corolla-lobes stand free as eight papilla-like bodies on its border. In the open pistillate flower of *Fevillea* the summit of the ovary is about 5 mm. in diameter and forms the floor of the flower from which the short styles emerge separately and bend outward. The placentae are first noticeable as small vertically running ridges between the incipient carpels, that is the point at which we may conceive the edges of the carpels as uniting. These ridges grow in toward the center of the cavity and meet first in the upper part of the ovary (*fig. 7*) and thus close the cavity. The placental ridges meet later in the lower part but between them there are maintained three spaces in which the ovules are freely suspended until some time after fertilization, when the growth of the seeds and the expansion of the tissue of the pericarp invests them with the pulpy tissue. When the ovules first appear on the placenta they stand out at right angles to the axis but later they become pendent and flexed back along the sides of the dissepiments. Ordinarily two or three ovules are borne on each lobe of the placenta, making about twelve or fifteen in each ovary.

Melothrieae

The pistillate flower of *Melothria* arises as a lateral outgrowth similar to that of *Fevillea.* It is at first rounded at the apex, but soon becomes flattened and concave. About as soon as the depression becomes distinctly discernable, five lobes appear upon its border, and these increase rapidly in size and soon overtop the concavity. By this time there have arisen, alternately with these lobes, five others on the inside of the cup and just below the insertion of the outer circle. (*fig. 1, C*). This figure also shows the beginning of the staminodia which here appear as slight elevations below the second circle of protuberances. The placentae appear in figure *1*, *D*. Up to this time, and much later, in fact, there is little or no growth of the central tissue of the axis. After the first circle of lobes appears there is an increase in the growth of the outer tissue, which becomes often clearly marked off from the more central tissue by reason of its larger cells. The growth of this outer layer carries up with it the younger lobes so that they appear later to be an outgrowth of its inner surface. The most rapid zone of growth is just below the second circle of lobes or the corolla-lobes, so that the calyx and corolla soon become lifted above the young placental lobes. Later another zone of elongation is to be seen below the first placental lobes, so that the latter become considerably removed from the bottom of the cup, and finally grow up into the style and stigma. The first series of lobes formed gives rise to the calyx.

After elongation in the second zone has proceeded for some time the longitudinal ridges of the placentae appear, three in number reaching to the bottom of the cup. These grow in toward the center, become later angular by reason of mutual pressure and each bears two rows of ovules, which finally assume an anatropous position with the micropyle directly toward the wall of the ovary.

Cucurbiteae

In the development of the pistillate flowers *Bryonopsis* displays in its earliest stages the same features as those which characterize *Fevillea*. A lateral outgrowth becomes flattened at the end and soon the flat surface becomes concave. Almost as soon as the concavity is perceptible the origin of the parts of the floral envelope are manifest. Five lobes arise in an outer circle, and these lobes are alternate with five others in an inner circle. At this time inside of the inner circle of organs there is but a very slight concavity and no appearance of carpels or staminodia.

In the formation of the placenta *Bryonopsis* resembles *Fevillea*. Three ridges arise in the concavity and traverse its sides vertically at equidistant points. These ridges soon meet at the center and ultimately fill all the cavity except three narrow spaces running out from the center laterally. The placental folds simply come into contact but do not fuse. As growth proceeds in the placenta and in the outer tissue of the ovary it is retarded in those parts which might be considered the bases of the longitudinally running ridges. The three radiating narrow spaces between the placentae now become expanded at the outer border so that the ovary in transverse section appears to be divided internally into three parts by radiating fissures with a T-shape extremity. This is the beginning of the formation of the free ovule-bearing edge of the placenta. These ovule-bearing edges lie in the angles of the T. This modification of the internal structure is confined to the central part of the ovary and does not extend upward through the style. A triangular passage-way is, however, maintained through the style to the stigma, thus providing an open stylar canal.

The angular borders of the placenta soon show a condensation of the protoplasm of their constituent cells, followed by the appearance of the ovules as slight swellings along the borders. Only one row of ovules is developed on each lobe of the placenta, so that in any transverse section of the ovary it would not be possible to find more than six ovules.

Only when the ovules are quite young is one likely to find as many as six, owing to the fact that the subsequent growth and elongation of the ovary disturbs somewhat the original uniform order, and the requirements of space render necessary a more economical arrangement, which is attained by the overlapping of the seeds of contiguous placentae, which takes place to some extent. The position which the ovule ultimately assumes is one in which its axis is coincident with a radius and its micropyle is directed outward. In the earliest stages of the ovule its axis lies at right angles to the radius which passes through its center. In the process of growth the apex of the ovule is soon directed toward the center of the ovary and finally toward the periphery so that the apex describes during its growth an arc of 270°. Unlike the ovules of *Fevillea*, those of *Bryonopsis* remain essentially perpendicular to the axis of the ovary, a condition to be found in most of the Cucurbiteae.

The process of development runs about the same in other members of this tribe. The cup-like depression appears in the young flower on the inner surfaces of which three inwardly projecting ridges meet in the line of the floral axis and produce the placental folds on the right and left sides of each ridge. While one finds in *Bryonopsis*, *Trichosanthes* and *Momordica* a single line of ovules in each placental border, the case is different in *Citrullus* and *Cucurbita*. In these genera what was originally a single placental border, has become doubled or trebled so that there are two or three longitudinally running ridges in each plant instead of one. Consequently a transverse section of the ovary shows a series of ovules of different sizes borne on each reflexed margin of a carpel. The ovules are smallest near the margins of the carpels, and largest always on the portion of the placenta nearest its origin. Between these two extremes a gradual progression in size is maintained, the internal development and differentiation of the ovule keeping pace with its outward development. The difference in size is lessened, however, by the time the flower opens, so that the opportunities for fertilization are about equal so far as the degree of development is concerned. *Cucumis* does not show the same degree of difference in the development of the placenta and ovules which is characteristic of *Cucurbita* and *Citrullus.* A transverse section of the developing ovary shows fewer ovules and these more equally developed, and more uniformly placed with reference to the radii of the section.

In *Luffa* the pistillate flowers are early differentiated from other lateral outgrowths by the usual features. Sepals, petals, staminodia and carpels may all be recognized in the longitudinal section of a young flower. Such a section through an ovary about one mm. in length shows the incipient style and the downward prolongation of the placental lobes below the region of their origin. This prolongation may be one and a half times the length of the stylar canal at this stage. When the ovary has attained the length of three mm., slight elevations along the placental borders mark the origin of the ovules, which later appear in two ranks on each border. The stylar canal does not elongate in a proportional rate with the other structures, for in an ovary of this size it is barely one fourth of the length of the lobes of the placenta. The ovules gradually turn the micropyle toward the periphery of the ovary, but by the time the megaspore has undergone division the funicle of each ovule has become much elongated. The ovules show an unequal rate of development, those on the proximal portions of the placenta being farther advanced than are those on its extreme borders.

Benincasa and *Lagenaria* exhibit features in the development of pistillate flowers similar to those of *Luffa* and need not here be described in detail. In these, however, the placenta bears several rows of ovules instead of two as in *Luffa.* The ovules are much like those of *Cucumis*, borne on an elongated funicle. In other respects, however, they are much like those of most other members of this family, possessing a broadly conical nucellus, with outer integument strongly developed and the inner one hardly visible except in younger stages.

Sicyoideae

In the Sicyoideae, the distinguishing characters of which are to be found mostly in the androecium, one is impressed by the variations in the forms of the pistillate flowers. *Coccinia* presents a case in which the structure of the ovary is not essentially different from that of some of the Cucurbiteae. Not only are the developmental features similar, but one finds in a transverse section of a young ovary that it is distinctly tricarpellary, and furthermore, that on each placental border, not one only, but two rows of ovules are present. This condition is quite different from that which is to be found in other members of this tribe, viz., *Sicyos* and *Micrampelis*.

The pistillate flowers of *Sicyos* are borne in dense clusters, several flowers being sessile at the end of a common peduncle. Sections of the growing tip of a flowering shoot pass through several of these clusters at various stages of development. As the flowers project in all directions from the end of the peduncle, it follows that they appear in the preparation sectioned in many different directions. The pistillate inflorescence first appears near the growing point of the shoot in the form of a blunt outgrowth in the axil of a leaf-rudiment. This outgrowth soon develops on its surface numerous papilla-like elevations which continue to increase in height. These are at first rounded at the end, but later the end becomes flattened perpendicularly to the axis. This flat surface becomes later depressed at the center by reason of the more rapid growth in the peripheral region, and the depression gradually deepens into a cup. About the time the depression has reached a depth a little greater than the transverse diameter of the ovary, the corolla-lobes appear near the top in a circle running parallel with the upper border and on the inside. This is followed a little later by the appearance of three elevations a little lower down and also in the inside. As growth proceeds the border or rim of the cup becomes divided to form the calyx and the next circle of organs forms the corolla. The three outgrowths which arise from near the bottom of the cup give rise to the gynoecium. They grow in toward the center until they meet and then become prolonged upward to form the style and stigma. From one of these outgrowths a small elevation may be early distinguished, which marks the rudiment of the ovule. This elevation bends down toward the base of the ovary and soon fills the cavity of the ovary before there is any differentiation of integuments. By the time the cavity of the ovary is filled the young ovule is a downward projecting lobe and about the time that the integuments are first distinguishable it begins the turning which finally brings it to the anatropous position. The turning takes place toward the side on which the ovule had its origin, the apex of the nucellus being turned underneath and finally brought up toward the placenta, so that its final position is anatropous, with the micropyle directed toward the style. The single ovule entirely fills the ovarian cavity, but it is at all points separate from the wall except at the placenta.

The development of *Micrampelis* presents some very interesting differences from the foregoing types. The pistillate flowers are borne singly and each normal ovary contains four seeds. In the mature fruit the micropyles of the ovules are directed toward the base of the ovary, the opposite, in this respect, of *Sicyos*. The earlier stages in the development of the ovary resemble those of *Sicyos*, in the manner of the formation of the cup and the development of the two apparent rings inside the cup. The upper ring grows upward forming style and stigma, as in *Sicyos*. The lower ring becomes modified in a very different way. The ovary here is evidently composed of two carpels and the inflexed borders of these carpels as usual become the placentae. What appears to be a ring is not actually such but opposite elevations which mark the edges of the carpels and which are more or less convergent horizontally. These elevations appoach from opposite sides and flatten against each other at the center, so that two lobes are formed each provided with two wings. On the lower portion of each wing an ovule arises in the usual manner. The apex of the nucellus is at first directed downward but gradually turns toward the axis of the ovary. The turning continues so that the micropyle is at one time directed toward the axis, later upward, and finally downward again by continuous turning in the same direction. As in *Sicyos* the cavity of the ovary is very early filled by the growing tissue and the ovules, but here also the stylar canal is maintained. While the turning of the ovule is taking place a torsion of the funicle is also going on so that the raphe instead of lying on that side of the ovule which is toward the median line of the carpel, is on the side toward the line of union of the carpels. The placentation, which is at first apparently basal and later central, is in reality parietal and essentially similar to that of the other types already considered.

Cyclanthereae

Near the growing point of the shoot, in *Cyclanthera*, there arise lateral protuberances (leaf-rudiments), and in the axils of these outgrowths other lobes appear which are the primordia of the inflorescences. The division of the axillary lobe into lesser lobes is soon apparent. One of these becomes a pistillate, the others all staminate flowers. The difference between the two can early be recognized. Both at first are flattened across the apex, but soon the staminate flowers are marked by a convexity within the circle of corolla lobes, while the pistillate flowers become more concave. In the pistillate flower this concavity deepens and the placenta appears as a broad ridge inside running parallel with the axis of the flower. This placental ridge soon fills the cavity and bears from ten to fifteen ovules in two lateral rows. The stylar canal, easily discernible in the earlier stages, is practically obliterated at the time of the fertilization. At this time the ovules stand almost perpendicular to the axis of the ovary with the micropyle directed outward near the line of union of the carpel-borders.

EMBRYO-SAC

Fevillea

The first indication of the appearance of the ovules upon the placental folds may be noted at the time when the young pistillate flower is slightly less than 1 mm. in length. Slight elevations along the reflexed margins of the carpels indicate the positions of the individual ovules. At this time the whole placental region shows distinctly the characteristics of meristematic tissue. As Warming[86] has shown, the growth of the ovular "Anlage" proceeds by the division of subepidermal cells, and he has pointed out that in some these divisions occur chiefly in those cells situated immediately below the epidermis, and in others in the third layer of cells, or the second below the epidermis. Among the Sympetalae the former type is represented by *Senecio*, the latter by *Symphytum*, *Verbascum*, *Lamium* and others. A section through the ovary of a very young flower of *Fevillea*, before there is any indication of the formation of ovules, shows that the multiplication of cells is chiefly in the region several layers of cells deep under the epidermis. There are no very regular subepidermal layers of cells at this period, divisions occurring in different planes. The divisions, however, predominate in the plane tangential with reference to the ovary wall, so that the central region of the placenta shows radiating rows of cells which flex to right and left toward the borders from which the ovules arise. When, however, the formation of ovules begins to be evident, a layer of subepidermal cells of considerable regularity is noticeable, and divisions occur abundantly in this layer as well as in the epidermis in a radial direction. Sometimes the second and third layers assume a degree of regularity, all of which is merely an expression of the direction of growth at this time. The subepidermal layer remains distinct for some time while divisions of its cells are taking place in radial planes. Even after tangential walls are formed in these cells, the limits of the original subepidermal layer are still apparent in the older and thicker walls which toward the outside separate it from the epidermis and toward the inside from the more deeply lying tissue. The first tangential walls may be formed in this layer at the apex of the nucellus.

The first suggestion of the origin of an integument is to be seen in the enlargement radially of the cells of the epidermis at two points, as appears in section not far removed from the apex of the nucellus. This collar-like growth is next augmented by a tangential division of the epidermal cells at its summit and later by the divisions of those beneath. The inner integument is clearly to be recognized before the outer one and rises above the nucellus as a thin collar two layers of cells in thickness and divided entirely from the epidermis. By the time that the inner integument has formed a distinct ridge around the young ovule, the expansion of the mass of tissue at its base denotes the beginning of the outer integument. The growth of this integument soon exceeds that of the inner and before there has been much differentiation of structures within the nucellus it has far overtopped the inner integument and the nucellus. The ovule, in regard to the relative size of its different vegetative parts, is unlike that of other sympetalous flowers (Boraginaceae, Labiatae, Scrophulariaceae, Valerianaceae, Compositae), in which there is a reduction of the nucellus and inner integument. In its earlier stages especially it bears far more resemblance to those of some of the Choripetalae (Rosaceae, Geraniaceae) than to those of other groups to which the Cucurbitaceae are regarded as more closely related. Figure *13* shows the relative development of the different parts of the ovule. The integuments present the rather unusual appearance of being much elongated and standing free for a considerable distance above the nucellus. The micropyle is a wide canal up to the time of fertilization and up to this time the inner integument is always distinct from the outer. Soon after this period, however, when there is the most rapid development of structures within the nucellus, it becomes almost obliterated at the sides of the nucellus, though plainly visible toward the chalaza and at the micropyle. In the latter place it has practically filled the micropyle by a proliferation of cells on its inner surface. At about the time of fertilization the outer epidermis of the outer integument begins the tangential divisions which, as Harz[37] has described for other Cucurbitaceae, give rise to the characteristic histological features which are well known in the ripe seeds of this family. Subsequently to this period, growth in the ovule is principally in the outer integument, the nucellus enlarging mainly by the expansion of cells already formed.

When the first periblem layer in the very young ovule has assumed some degree of regularity, a cell situated immediately below the epidermis at the apex of the young nucellus increases in size and becomes clearly differentiated from its neighbors (*fig. 9*). The first division of this cell is tangential and a single tapetal cell is cut off. The inner daughter-cell, the megaspore-mother-cell, remains undivided and enters upon a period of growth. The tapetal cell in the meantime divides by walls both perpendicular and tangential to the epidermis, so that the spore-mother-cell soon becomes covered by a row of cells to the number of ten or twelve. At this time divisions are going on in the cells to the right and left of this row so that several rows of cells are formed and the appearance is such as is shown in figure *12*.

Both first and second divisions of the spore-mother-cell were observed. Four spores are formed, but only the lowermost one is functional. The four megaspores were sometimes observed soon after the division when they were all in good condition and again when the three uppermost ones were beginning to disintegrate (*fig. 16*). In figure *16* the two upper cells appear a little more advanced in the process of disintegration than does the third cell. Usually light walls are formed between the potential megaspores, but sometimes none are formed in the first division. It might be inquired as to whether this condition does not represent the second division of the megaspore rather than the second division of the megaspore-mother-cell. It may be answered that such can hardly be the case, inasmuch as no potential megaspores were observed nor any cells that could be taken as such, upon this assumption. The division into four megaspores occurs with so great a regularity in this type that there is hardly a chance for such an error.

The functional megaspore enters upon a period of enlargement and divides to form the embryo-sac in the usual manner. The definitive embryo-sac is smaller than that found in some of the other genera. As the fixation of the material in the definitive embryo-sac stage was not very good, no description of its minute structure will be attempted. It presents about the same general features as are found in the embryo-sacs of the other genera studied. The endosperm nuclei fuse before fertilization. The antipodal cells are noticeable only for a short time. The egg-apparatus consists of two synergids, pyriform, vacuolated, with striated hyaline upper portions and a centrally situated nucleus. The oösphere as in other cases presents a much vacuolated appearance in its upper portion and a small nucleus embedded in the thicker protoplasm of its lower portion.

Preparations showing the process of fertilization were not secured. Some preparations showing young embryos were obtained, however, and the embryos appear to differ a good deal from those of the other genera. A small mass of cells is to be seen lying close against the tissue of the nucellus in the embryo-sac. The divisions have produced an embryo of about ten to twelve cells, of which a part are shown in figure *20*. The first cleavage-planes could not with certainty be determined in this case, but they are apparently transverse.

In the case represented by figure *24* the cell-formation of the embryo is quite regular, but in most cases the embryo consists of a rounded mass in which no definite system of cleavages is apparent (*figs. 20* and *22*). In figure *20* the line *ab* appears to represent the oldest cleavage-plane, as it is the thickest of the walls there apparent. But in this case no suspensor appears; which is the condition in the majority of the Cucurbitaceae. Later embryonic stages were not observed. The endosperm is only a very thin peripheral mass, at the time in the development of the embryo indicated by figure *21*. Its nuclei are very small and are not clearly distinct, but are thickly scattered through a densely granular protoplasm. The cavity occupied by the embryo-sac rapidly expands after fertilization and the endosperm remains closely applied to its periphery. At the micropylar end the cavity is oval, narrowing quickly to a narrow tube which stretches toward the chalaza, the tissue of the nucellus disintegrating before it.

Melothria

The ovule originates in *Melothria* as a rounded elevation on the right or left flank of the placenta. By growth of the hypodermal cells at the apex of this elevation, its cells are brought into a serial arrangement in rows running back toward the base of the rudimentary nucellus. The spore-mother-cell apparently originates in this form as in *Fevillea*. The earliest stage observed is represented by figure *25*, which shows the relative size of the spore-mother-cell and its relation to other parts of the young ovule. While the subsequent stages of development were not fully represented in the preparations obtained, enough was observed to give a more or less adequate idea of the course of development.

About the time when the spore-mother-cell appears, the ovule begins to turn toward the placenta and the inner integuments begin to show. At this time the apex of the nucellus is directed toward the center of the ovary, thus having its long axis coincident with a radius. When the embryo-sac has reached the four-celled stage as shown in figure *26*, it has turned to a position at right angles to a radius. Numerous preparations showing four cells in the embryo-sac were obtained, but in none of these was there any evidence of degenerated potential megaspores. If such structures were present they must have disappeared early. By the time the embryo-sac has become ready for fertilization the micropyle is directed outward. The embryo-sac in all stages in *Melothria* is very minute and does not lend itself to the study of more than its grosser morphological features. It consists (*fig. 27*) of an egg-cell, two synergids and two polar nuclei, at a time when the pollen-tube can be detected in the tissue just outside the micropyle. The synergids are long, narrow and vacuolated in their lower portions. The egg-cell is relatively large, but consists of only a thin protoplasmic sac with the nucleus at the lower end. The polar nuclei are largest and surrounded by a dense mass of protoplasm. No antipodals could be found.

Several stages in the development of the embryos were observed. The earliest walls found are transverse, but these are soon succeeded by longitudinal divisions (*figs. 28–31*), first in the distal cell of the series, and later in the short or rudimentary suspensor. The cells of the suspensor are never many, and the few that are formed are soon disorganized (*figs. 30, 31*). The first cleavage of the proembryos are quite regular (*fig. 31*), but the subsequent divisions are in no definite order, and a globular mass of cells is soon formed (*fig. 32*) in which no differentiation is apparent except that the epidermis is clearly defined and remains so. A beak-like prolongation in the proximal portion indicates the slight suspensor, which is not always connected with the wall of the embryo-sac cavity; the embryos usually appearing to be free in the micropylar end of the cavity. The spherical form of the embryos is maintained until they reach a size visible through an ordinary hand-lens. An elongation of the mass then begins and the cotyledons soon appear as two lobes at the distal extremity (*fig. 33*). In the next later stage observed the cotyledons had assumed the proportions indicated by figure *34*. Still no differentiation of periblem and plerome could be detected, but the initial stages in the formation of the root-cap were visible.

The endosperm begins to form early after fertilization. The complete fusion of the polar nuclei was not observed, but if it occurs it must be at about the time of fertilization. By the time the first cleavage of the embryo has been completed, the endosperm has formed a thin sac which rapidly displaces the surrounding tissue of the nucellus. As the cavity in the nucellus expands the endosperm keeps pace with it, forming always a thin layer closely applied to the sterile tissue. The displacement of the tissue of the nucellus, however, is mainly in the direction of the chalaza, and even when the embryo is comparatively small (*fig. 32*) the nucellus is penetrated by a thin string of endosperm which reaches almost to its base. When the embryo is older (*figs. 33, 34*) this string of endosperm becomes more evident, but the lateral tissue of the nucellus, that is the tissue along its sides, is only slowly dissolved. The nucellus and in fact all parts of the ovule enlarge rapidly, so that at the stage of embryonic development represented by figure *32*, which is comparatively early, the ovules have already enlarged to many times their size at the time of fertilization, and the outer integument has already undergone considerable modification in the way of thickened cell-walls.

Apodanthera

The material available for the study of this form was somewhat fragmentary, consisting mainly of fruits and seeds in rather advanced conditions. The early stages showing the development of the gynoecium and the origin of the sporogenous tissue were entirely lacking. Figures *35–43* represent fairly well the conditions observed in this material, which include mature embryo-sacs and embryos in various stages of development.

The development of the ovary in *Apodanthera* appears to conform to the usual type so far as could be determined from the material at hand. Each placental flank bears a row of ovules which at the time of fertilization lie with their micropyles directed outward. At this time the placentae have entirely fused where they come into contact at the center. The ovules at this stage are nearly circular in longitudinal section, the outer integument being thick (about one sixth the diameter of the ovule), while the inner integument is but a thin layer, two or three cells in thickness.

The embryo-sac at the time of fertilization occupies but a small oval space near the micropyle. At this stage it consists of the usual structures though with certain individual characteristics worth noting (*fig. 35*). The most conspicuous element of the embryo-sac is its endosperm nucleus. This is relatively large; it is marked also by its chromatin content and large nucleolus. The cytoplasm surrounding the nucleus is quite dense and radiates from the center in strands separated by numerous vacuoles. The egg-apparatus in its general form and structure conforms to the types already described. The nuclei and the vacuoles of the synergids are quite small as compared with those observed in some of the other forms. In this case antipodals were observed, though only as vestiges (*fig. 35*).

Immediately after fertilization certain marked changes may be seen in the character of the embryo-sac. It expands, much as in other cases, into a sac-like structure, but soon becomes filled with numerous refractive starch-grains, among which occasional free nuclei are easily seen (*fig. 36*). The nuclei and the starch-grains are both more abundant in the upper portion of the embryo-sac. The nuclei have lost some of the features which characterized the original endosperm nucleus, being here almost devoid of any chromatic substances, aside from the large nucleolus. The starch which forms so conspicuous a part of the endosperm is, however, of only transient duration. The endosperm expands rapidly toward the chalaza and laterally and soon becomes a thin layer of vacuolated protoplasm, in which the nuclei are still free. The starch at this stage (*fig. 39*) has entirely disappeared. The lower extremity of the endosperm soon assumes the appearance of a haustorium. In this condition it appears as a finger-shaped, vacuolated mass, containing several nuclei (*fig. 39*), before which the tissue of the nucellus breaks down. This appendage, however, disappears in the course of development (*fig. 41*), but in the case just cited the nucellus presents no further obstacle to the development of either endosperm or embyro. At this stage the endosperm has become entirely cellular, a mass of loose tissue whose outer surface is composed of a layer of cubical or tabular cells.

The embryo does not materially differ from those of several other forms examined. An earlier stage than that represented by figure *37* was not observed. Here can be seen a short suspensor with some longitudinal divisions and the epidermis marked off to some degree. The subsequent growth of the embryonic mass results in the assumption of a pyriform shape, which gradually gives way to a more rounded form. The cotyledons appear at a slightly later stage, when the distal portion of the mass becomes somewhat flattened. The differentiation of structures at the apex of the radicle does not appear, however, until some time later, as shown in figure *42*, in which the root-cap and dermatogen may be distinguished. At the stage represented in figure *39* the form of the ovule is materially changed. It elongates rapidly during this period and when the early embryonic differentiation appears (*fig. 43*) has practically assumed the proportions of a ripe seed.

Bryonopsis

In the case of *Bryonopsis* there arises a single row of ovules upon each flank of the placenta. Beneath the apex of the incipient nucellus the spore-mother-cell may be found at an early stage. Although an entirely complete series of the early stages was not obtained, the conditions that were observed indicate that the spore-mother-cell arises in the usual way. In the earliest stage observed but two tapetal cells were found separating the mother-cell from the overlying epidermis. Figure *44* shows a condition slightly later. About this time the inner integument may be detected arising from the epidermis in a ring below the apex of the nucellus.

By the periclinal divisions of the tapetal cells and those adjoining, the spore-mother-cell soon becomes centrally situated in the nucellus (*fig. 45*). It also becomes considerably elongated and soon divides into four megaspores of which the lowermost is the functional one (*fig. 46*). The three upper cells disorganize and may be seen in later stages as a dark mass overlying the young embryo-sac (*fig. 47*). The development of the parts of the ovule keeps pace with that of the internal structures and when the condition represented by figure *46* is reached, the inner and outer integuments have overtopped the nucellus, the former thin and composed mostly of two layers of cells, the latter thick and showing some differentiation of vascular tissue.

An embryo-sac of two cells is shown in figure *47* and another of eight cells in figure *48*. In the megaspore (*fig. 46*) the nucleus is more prominent than in any of the subsequent stages, and as growth of the cell proceeds, vacuolization follows to a large extent. After the first division the two resulting nuclei are separated to opposite ends of the embryo-sac by the large vacuole (*fig. 47*), and the nuclei resulting from subsequent divisions are similarly disposed (*fig. 48*). In the preparation represented by figure *48* the earlier steps in differentiation were visible. The synergids, oösphere and upper polar nucleus were easily discernible. In the antipodal region not so much difference was visible but the polar nucleus appears the most conspicuous of them all. The definitive embryo-sac has some characters in common with those previously described. The synergids are slender, pointed at the upper ends and vacuolated in the broader, lower portion. As in other cases the upper portion bears a hyaline striated aspect. The oösphere is somewhat more conspicuous than in many other cases and the polar nuclei less so. The antipodals remain quite evident up to this time. Figure *49* represents a condition in which the polar nuclei are in contact but not united. The complete fusion of these was not observed. At the stage represented by figure *49*, which is prior to fertilization, the embryo-sac is packed with starch which persists until some time after fertilization (*fig. 50*).

The ovule at the time of fertilization is oblong in form, its length being approximately three times its broadest diameter. Not until fertilization has been accomplished is the growth very rapid. Then, however, it expands rapidly, its growth in length being considerably greater than that in breadth. The embryo-sac, at the time indicated by figure *49*, occupies the center of the upper half of the nucellus, the cells immediately surrounding it appearing somewhat crowded or compressed. After fertilization, however, this tissue at once gives way before the expanding endosperm. The tissue surrounding the embryo-sac now colors a little more deeply when the preparation is stained. While growth in length is proceeding rapidly the nucellus becomes cleft from apex to chalaza, though apparently due to the tension of growth in its peripheral region and not to any influence of the endosperm.

The endosperm, after fertilization of the oösphere, soon becomes distributed peripherally (*fig. 50*), and forms an exceedingly thin layer for some time. The starch may still be found in simple and compound grains distributed irregularly in this layer of protoplasm. During this period the nuclei increase considerably in size, as can be seen by a comparison of figures *49* and *50*, which were drawn to the same scale. At this time the endosperm is non-cellular, but the nuclei soon become separated by walls throughout, and in its upper portion it appears as shown in figure *51*, at which stage all traces of starch have disappeared. The cells of the endosperm are most compact in its outer portion, those more centrally situated possessing only a thin layer of cytoplasm which lines the cell-wall.

Only two conditions of the embryo were observed in *Bryonopsis*. After fertilization the oösphere enlarges to a considerable degree before dividing (*fig. 50*). The earlier cleavages were not discovered in any of the preparations, but a later condition (*fig. 51*) was found which shows the embryo to be at one stage almost spherical in form with no visible suspensor. No differentiation of structure is apparent at this stage except the epidermis. From this condition it may be inferred that the differentiation of form and structure proceeds in this form about as in some of the other types described. In view of the ephemeral character of the suspensor in the other forms it is quite possible that such a structure may be formed here, but later lost. Cell-division at this stage proceeds at random and only at opposite ends is there any apparent regularity in the sequence of the cell-divisions. Cells at the proximal end appear at this stage to initiate the process by which the root-cap is differentiated, and at the distal end to form in that order which, in later embryos, shows them arranged in layers parallel with the epidermis.

Trichosanthes

Trichosanthes presents certain features which quite strongly suggest those found in *Bryonopsis*. In the origin of the ovule upon the placenta the conditions are quite similar, each flank of the placenta bearing a single series of ovules. The first indication of the formation of sporogenous tissue may be seen when the ovule is still merely a small elevation on the placenta. At this time the archesporium, consisting of a single cell, appears immediately below the epidermis at the apex of the young nucellus (*fig. 52*). It may readily be recognized by the usual characters which mark sporogenous tissue. At this stage no differentiation of the ovule is apparent, but its rapid growth results in the distribution of its cells in confocal series as seen often in longitudinal section of the organ.

The hypodermal archesporial cell divides to form the tapetum and the spore-mother-cell. The former continues to divide by periclinal walls, thus forming an axial row of from ten to twelve cells. The sporogenous cell enlarges in the mean time, acquiring a nucleus which occupies most of the space within the walls of the cell (*fig. 53*). The process of spore-formation appears to be quite regular in *Trichosanthes*, that is the functional megaspore is one-fourth the spore-mother-cell. The first division results in the formation of two cells, of which the outer one, however, does not again divide. It immediately disorganizes, while the other cell, the lower of the two, proceeds to divide again transversely. The spindle of the division may be clearly seen, while the adjoining cell is in the process of deterioration (*fig. 54*). The outer cell resulting from the second division also disorganizes, so that the functional cell is the lowest of the series (*fig. 55*). In this case the remains of the discarded cell from the first division are still visible.

It is quite probable that the development of the embryo-sac from the spore thus formed proceeds in the usual manner, though some of the steps were not observed. The definitive embryo-sac is represented by figure *56*. In this case the egg-apparatus presents the usual features. The synergids are rather more conspicuous than in the preceding form (*fig. 49*), and the oösphere less so. The antipodals are large and stain deeply, though the latter fact is apparently due to their partially disorganized condition. The endosperm nucleus is formed by the union of the two polar nuclei, though the two larger nucleoli thus contributed remain distinct, so far as it was possible to observe. The embryo-sac at this stage does not present the much-vacuolated appearance which was characteristic of some of the foregoing forms (*Apodanthera*), but instead is very compact and like that of *Bryonopsis* is filled with starch. This starch is conspicuous in the embryo-sac until after fertilization and then soon disappears (*fig. 57*). At this time the embryo-sac begins to expand and the surrounding tissue is affected for some distance, as indicated by its staining properties. As appears in some of the cases already described, the endosperm becomes modified in character as the embryo begins to form. It not only loses its starch but becomes distributed as a very thin sac closely approximated to the rapidly receding tissue of the nucellus. The nuclei are at first free in the endosperm and irregularly distributed through it. They are not nearly so conspicuous in size and chromatic content as was the original nucleus. In a still later condition of the endosperm the nuclei enlarge somewhat (*fig. 60*), but it is to be noted that with the progress of development the nucleoli constantly diminish in size. The endosperm has become entirely cellular before the embryo has reached any considerable degree of development (*fig. 59*). A few cells from the upper end of this mass are shown in detail (*fig. 60*). In these the scant cytoplasm is a very prominent feature.

The embryo proceeds from a fertilized oösphere, presumably. The process of fertilization was not observed, but conditions in the embryo-sac appear to point to the oösphere as the functional cell. What seem to be disorganized synergids are plainly visible in the embryo-sac after the embryo has begun to form. At any rate the embryo begins its growth by a series of transverse divisions (*figs. 57, 58*). Of the cells thus formed the proximal ones act as a suspensor of very transient duration. The distal cells enlarge to form a pyriform mass in which, at the stage indicated by figure *61*, there is no differentiation in any structure, unless it be a layer of very irregular epidermal cells. The next stage observed in the formation of the embryo is represented by figure *62*, which shows the cotyledons partly developed and the root-cap differentiated. In an embryo of this age there is no tissue differentiation beyond that of root-cap and epidermis. In the radicle, however, the cells have become arranged in regular series converging in the apical meristem.

The development of the parts of the ovule presents no features of importance differing from those already described for some of the foregoing forms. As in other cases, also, the nucellus expands rapidly after fertilization and gives way before the growing epidermis. The seed attains the proportions of maturity before the embryo has proceeded beyond the condition represented by figure *62*.

Momordica

As in the case of *Bryonopsis* and *Trichosanthes*, the ovules of *Momordica* arise as small elevations on the right and left flanks of the placental ridges. The origin of the archesporium was not observed, but the spore-mother-cell was found in an advanced condition (*fig. 63*). In this case it occupies a central position in the rapidly growing nucellus and is separated from the epidermis by three tabular tapetal cells. The nucellus at this time grows rapidly and the integuments cover only the lower half of it. These arise in the usual manner and by the time the embryo-sac is ready for fertilization they have closed over the top of the nucellus. Until some time after fertilization the outer integuments are relatively thinner than those of the other cases described, except *Fevillea*. The inner integument is always thin.

The division of the spore-mother-cell to form the usual potential megaspores was not observed, though there is evidence that it occurs. In stages somewhat later, certain disintegrating masses were observed above the young embryo-sac, which were taken to be non-functional spores (*fig. 65*). An embryo-sac of two cells was observed, but none between this condition and fertilization. When the oösphere is mature the embryo-sac differs in some respects from the preceding forms. Figures *66* and *66a* represent parts of the same embryo-sacs. The synergids are much less vacuolated and are decidedly hyaline and striated in their upper portions. The oösphere is likewise more compact and the whole egg-apparatus is larger than in most other cases examined. No antipodals could with certainty be determined. If formed at all they must disappear quickly.

The endosperm nucleus is formed by the fusion of two polar nuclei. The nucleus thus formed is conspicuous for its size and chromatic content. Each polar nucleus has a very large nucleolus and these evidently become merged, as only one could be found in the endosperm nucleus. After fertilization the endosperm rapidly increases and the cells of the nucellus are gradually displaced. No starch was observed in the endosperm of *Momordica* at any time. As the endosperm grows, most of its substances become peripherally distributed with numerous small nuclei scattered through it. This condition is maintained for some time, while the expanding surface of the endosperm is gradually replacing the surrounding tissue. Sometimes a thin line of cytoplasm may be seen penetrating the tissue toward the chalaza (*fig. 68*).

About this time the ovule enters upon a very rapid period of growth, and the nucellus, no longer compact, is cleft by the endosperm, which extends toward the chalaza. The endosperm gradually assumes a cellular character, beginning in the region of the embryo. Only in the micropylar region is there any approach to compactness, most of the mass consisting of large thin-walled cells with small protoplasmic content.

The first cleavages of the embryo are transverse and a row of cells is thus formed (*fig. 67*). The subsequent divisions, however are for some time irregular and result in the formation of a globular mass of cells (*figs. 68–70*), in which no differentiation beyond that of the epidermis is visible. A later stage was observed in figure *71* in which the cotyledons were being formed. In this case the differentiation into root-cap, periblem and plerome was well under way. At this stage the dimensions of the mature seed are approximately reached.

Luffa

When the undulations, which mark the origin of the ovules, become evident upon the surface of the placenta (see text-figure *5*, *H*) the groups of cells lying beneath the apex of each incipient ovule present a highly meristematic character. One of these cells soon appears larger than its neighbors and possessed of a very conspicuous nucleus. Sometimes there may be two such in an axial row, the outer one adjacent to the epidermis. The first indication of an archesporium is not always clear. Sometimes the spore-mother-cell itself appears in the hypodermal mass (*fig. 72*). In such a case it is quite conspicuous but no very definite tapetum is apparent. Subsequent divisions of the overlying cells, however, are mostly in periclinal planes (*fig. 73*). Thus a tier of several cells is formed above the sporogenous cell. The latter increases in size (*fig. 74*) until it becomes about two-fifths the length of the nucellus.

The development of the ovule is rapid from the time when the first indication of the archesporium is apparent. When the spore-mother-cell is well differentiated (*fig. 72*) the ovule has developed a long funicle and the formation of integuments and nucellus is well under way (see text-figure *5*, *I*). The growth of the integuments now exceeds that of the nucellus and they soon enclose it. During this process the divisions of the spore-mother-cell take place.

The manner of division of the spore-mother-cell recalls that of *Trichosanthes*. Of the cells resulting from the first division the outer one degenerates, while the inner one proceeds to divide again (*fig. 75*). The figure just cited shows the conclusion of the second division and the deterioration of the upper of the two cells thus formed. The functional megaspore immediately begins to enlarge preparatory to its first division, which is represented completed in figure *76*. The succeeding divisions are quite regular and the embryo-sac is formed in the usual manner by three successive divisions of the megaspore (*figs. 76–78*). In this form the migration of the polar nuclei begins before any differentiation of other structures is evident within the embryo-sac (*fig. 78*). At this time the embryo-sac is centrally situated in the nucellus, over which the integuments are slightly elevated. Conditions of the embryo-sac like those shown in figures *76*, *77*, and *79* may be found almost in the same section. In such cases, which are usual, the degree of the differentiation of the parts of the ovule is about the same in each, though they vary in size, the more advanced embryo-sac occupying the larger ovule. The difference in the degree of development of the embryo-sac and in the size of the ovule is probably associated with some condition of nutrition, inasmuch as such differences are directly correlated with the position on the placenta. When the egg apparatus has become fully differentiated the embryo-sac occupies the center of the upper half of the nucellus, surrounded on all sides by several layers of sterile cells. The pyriform nucellus is surmounted by a slender beak which passes up through the micropyle. At this time the inner integument consists of two layers of cells, the outer one almost as thick as the nucellus.

In the embryo-sac at the time of fertilization we find a very conspicuous egg-apparatus, which extends over nearly two-thirds the length of the embryo-sac. The oösphere is similar to other cases described, inasmuch as the nucleus occupies its lower portion and a large vacuole fully three-fourths of its volume. The synergids are peculiar in the extent of their vacuolization (*fig. 79*), the nucleus and cytoplasm in each occupying but a small space in the upper end. Here we may note also an absence of the hyaline and striated condition in that degree which characterizes some of the forms already cited.

The antipodals are of quite ephemeral character. They were not observed to persist after fertilization, and usually begin to disorganize prior to that event (*fig. 79*).

The formation of the endosperm apparently has its origin in the usual process, by the fusion of two polar nuclei. While the completed fusion of the polar nuclei was not observed in any case, they were observed in contact. In this condition they were surrounded by a mass of cytoplasm filled with starch-grains. After fertilization the endosperm expands rapidly and displaces the adjoining tissue of the nucellus. Before the first cleavage of the embryo has taken place the endosperm has assumed the usual sac-like form, the nuclei scattered through a densely granular cytoplasm. Starch-grains are still abundant (*fig. 80*) and are more frequently of a compound character. The cell-walls of the nucellus in contact with the lower end of the endosperm show evidences of disintegration. The endosperm soon loses its starch and becomes finely vacuolated (*fig. 81*).

But two stages of embryonic development were observed. The oöspore (*fig. 80*) presents a rather unusual appearance, being large with conspicuous vacuoles. The first cleavage is transverse (*fig. 81*). Of these two the basal retains the characteristics of the oöspore, the other is more densely granular.

Cucumis

The earliest stage observed in the formation of the embryo-sac of *Cucumis* was that represented by figure *82*. Numerous preparations of ovules at about this stage of development were obtained and it seems evident that the spore-mother-cell arises in the usual manner. The tapetum which is formed consists in the earlier condition of a few tabular cells which suffer division by periclinal walls, thus forming an axial row of cells. By the time that the divisions of the mother-cell occur the nucellus has assumed an oval form and the sporogenous cell is covered by the several parietal layers of the nucellus. The ovule at this time is borne at the end of a long funicle and has almost completed its turning to the anatropous position. The integuments have exceeded the nucellus in height. The parts of the ovule are of relative proportions similar to those of *Luffa* and some others.

The divisions of the spore-mother-cell now ensue. The first division results in the formation of two equivalent cells which proceed to the second division simultaneously (*fig. 83*). From this point the development of the embryo-sac proceeds by the usual course. The usual structures are apparent as the time of fertilization approaches (*fig. 84*). The synergids are long and narrow, their tips hyaline and striated and their vacuoles small. As in former cases the nuclei lie immediately above the vacuoles and the structure above the nuclei to the hyaline portion is apparently reticulate. The oösphere resembles a synergid in size and form but differs in the character and position of its vacuole and nucleus (*fig. 84*). The antipodals are three in number and distinctly visible at this stage, and show less evidence of disintegration than in some of the forms previously cited. Here they appear perfectly normal though not large. No evidence could be found, however, of their existence beyond the time of fertilization.

At this time the nucellus is flask-shaped, the bulb-like portion surmounted by a long slender beak. The embryo-sac and its associated structures are quite small in this species of *Cucumis;* the embryo-sac in particular requiring large magnification to bring out the details of its structure.

The polar nuclei migrate to a position just below the egg-apparatus, where they come into contact and probably unite.

The mass of cytoplasm which surrounds them is densely granular and no evidence of starch was observed in the embryo-sac at any time. Oil is abundant in the surrounding cells of the nucellus and to some extent also in the embryo-sac. The endosperm elongates in the direction of the chalaza as soon as fertilization has taken place, and for a time remains quite compact in the region of the embryo. The lower part, however, is a very delicate film which terminates in a sort of cup-like collection of cells like that shown in the case of *Apodanthera* (*fig. 39*). There is a rapid breaking down of all tissue in immediate contact with the embryo-sac even before there is any considerable enlargement of the nucellus. The sac-like character of the endosperm is soon assumed (*fig. 88*) and its cytoplasm becomes more and more vacuolated. The formation of cell-walls begins quite early and is complete before the embryo has attained any considerable degree of differentiation (*fig. 91*). In this condition it is compact upon the surface but composed of large cells within. The details of its structure are shown in figure *93*. Here it will be seen that the cells of the outer layer consist of a dense compact cytoplasm, while in the larger inner cells the protoplasmic content is distributed in a thin layer over the inner surface of the cell-wall. The significance of these facts will be discussed later. It will also be observed (*fig. 91*) that the end of the mass of endosperm in contact with the embryo is not of the same character as the rest of the superficial layer, but is composed of the large cells just described.

The first cleavages of the oöspore are transverse. Several of these divisions in succession result in the formation of a rudimentary suspensor (*figs. 85*, *86*). After the first two or three cleavages the subsequent divisions are anticlinal (*fig. 87*) and in somewhat irregular planes. The result is the formation of a pyriform mass (*fig. 90*), which increases in size until it is composed of several hundred cells, when the initial differentiation of root-cap and apical meristem is apparent. The formation of the root-cap is begun by a series of periclinal divisions at the micropylar end of the pyriform mass (*fig. 92*).

Lagenaria

Text-figure *5*, *K* represents the form of the placenta at the time when the first indication of an archesporium is apparent. Periclinal divisions beneath the epidermis at the apex of each lobe (*fig. 94*) result in the separation of the primary tapetal and sporogenous cells. These periclinal divisions occur in several hypodermal cells and thus several series are found radiating from the spore-mother-cell (*fig. 95*). The division of the tapetal cells and those in the parietal series follows until columns of ten to twelve cells are formed and the sporogenous cell becomes deeply situated in the tissue of the nucellus. In the meantime the integuments have about reached the top of the nucellus. Before the germination of the megaspore takes place they converge above the nucellus and the ovule assumes the form which it maintains until after fertilization.

Division of the spore-mother-cell occurs in the usual manner. The first division results in the formation of two equivalent cells, and each of these again divides (*figs. 96*, *97*). In this case, as in some of the foregoing, it is the lowermost of the four cells thus formed which becomes functional. It enlarges rapidly after these divisions and soon enters upon the series of divisions which provide the eight nuclei of the embryo-sac. The division of the four nuclei to form eight occurs simultaneously, as shown by figure *98*. Here the cytoplasm forms a peripheral layer and leaves the center open.

Differentiation of the eight nuclei is soon apparent (*fig. 99*), and the synergids begin to appear with their usual structure. The antipodals are quite distinct and remain so up to the time of fertilization (*fig. 100*). In the latter stage, however, they are visibly shrunken and soon afterwards disappear. The egg-apparatus differs in no essential from those already described.

An abundance of starch is now found in the neighborhood of the polar nuclei, which by this time have come into contact. In the preceding stage (*fig. 99*) no starch was apparent, hence it is evident that its formation must take place quickly as the time of fertilization approaches. The process of fertilization brings about the usual changes in the appearance of the endosperm (*fig. 101*) which loses its starch and forms a hollow sac. In this case as in others the nucellus breaks down rapidly in the vicinity of the embryo-sac and especially in the direction of the chalaza. The coenocytic character of the endosperm is not maintained in *Lagenaria* so late as in the other forms. The nuclei soon become separated by cell-walls (*figs. 103, 104*), and the endosperm becomes a solid mass. Where the surrounding cells of the nucellus are in immediate contact with the endosperm they break down, and even in the direction of the chalaza where they are not in contact with it. But a certain zone of tissue for some distance from the endosperm takes a darker stain and shows a denser cytoplasmic substance. The growth of the mass of endosperm is principally in length from this time on. The relation which it bears to the nucellus can be seen in figure *105*, which represents the upper one-fourth of that organ. The cleft extends to the base of the nucellus. The condition of the endosperm at this time is represented by figure *106*. The cellular structure on the outside is more compact and increases in thickness as growth advances, though the central portion of the mass remains more open in structure. The hardening of the endosperm begins in the upper portion and extends over the upper half of its surface at the stage indicated by figure *105*. The first divisions in the embryo are transverse (*figs. 101, 102*). In some cases the early cleavages are somewhat irregular (*fig. 102*) and the tendency is early towards an oval or pear-shape (*fig. 103*), with no regularity of cleavage-planes. As growth proceeds the embryo assumes a more oblong shape (*fig. 106*), and it is only at a much later stage that the beginnings of internal differentiation can be seen (*fig. 107*). Then the periclinal divisions in the proximal end indicate the initial stages in the formation of the root-cap. At this stage (*fig. 107*) the endosperm reaches about one-third the distance to the chalaza and the upper part of the nucellus is entirely disorganized. The lower part appears quite normal except for the breaking down of its cells along the median line. The ovule has now reached the dimensions of the ripe seed and the differentiation of its outer integument is well under way.

Benincasa

The formation of the archesporium proceeds in the usual way in *Benincasa*. The ovules appear to be rounded elevations upon the placental folds and when these lobes have become quite prominent the archesporium appears among the hypodermal cells at the apex of each lobe (*fig. 108*). The tapetal cells undergo few divisions before the sporogenous cell has become quite conspicuous (*fig. 109*). Divisions of the tapetal cells now follow until the spore-mother-cell becomes deeply seated in the nucellus. The integuments make their first appearance about the time the sporogenous cell is formed and bear about the same relation to the other structures as in the previous cases. By the time the first division of the megaspore nucleus has been completed the conical nucellus is covered by the integuments. At this time the incipient embryo-sac may be found at the base of an axial row of from fifteen to twenty cells.

The division of the spore-mother-cell was not observed. There is some evidence that such a division occurs in the appearance of what may be taken for the remains of non-functional spores. A black mass of what appears to be disorganized cells is plainly seen at the outer end of the young embryo-sac, but it soon disappears. It would seem also that it is again the lowermost of the series which becomes functional.

In the same section of an ovary, if not upon the same placenta, there may be found embryo-sacs in various stages of development. Embryo-sacs of two, four and eight cells may be found. The appearance of some of these may be seen in figures *110* and *111*. In many cases the most conspicuous element of the nucleus is its nucleolus which seems to embody all the chromatic substance present. Only in the case of the mother-cell are nuclear structures at all distinct (*fig. 109*). Figures *109*, *110* and *111* are all drawn to the same scale.

The embryo-sac as the time of fertilization approaches assumes a familiar aspect (*fig. 112*). Some of the more important features of the embryo-sac of *Benincasa* are the prominence of the egg-apparatus and the antipodals and the absence of starch, at least up to the stage of development indicated by figure *112*. The cytoplasm surrounding the polar nuclei appears to be rather scant and filled with numerous vacuoles. The complete fusion of the polar nuclei was not observed.

The antipodals, though quite prominent, are here also of only transient duration. They were not found in any preparations of material beyond the fertilization stage, and seem in this case to have no special function. As indicated in figure *112* they seem to be on the eve of disintegration.

The endosperm is quite similar to some that we have already found in previous cases (*fig. 114*). In this case also it is distributed in a sac-like form, which in the upper portions is of the usual thickness (*fig. 114*) but in the lower part is a very thin film. In this condition, before the first division of the fertilized egg, it has made considerable inroads upon the tissue of the nucellus. About ten nuclei have been formed and these are scattered about irregularly. The division of these nuclei, as usual, takes place simultaneously (*fig. 113*). The endosperm of *Benincasa*, like that of *Lagenaria*, soon forms a solid mass of cellular tissue (*fig. 116*). In this case also the peripheral portion becomes denser, and in the upper portion this takes place earlier than in the lower. The same figure shows the appearance of the cells of the nucellus when in contact with the endosperm. The first extension of the endosperm is toward the chalaza and while the growth is rapid in this manner it remains non-cellular. Upon formation of cell-walls, growth is retarded.

The oöspore remains for a short time undivided (*figs. 113*, *114*). A globular or pyriform mass of cells is soon formed (*fig. 115*). Preparations showing early cleavages were not obtained, but figure *115* appears to indicate that they may have been transverse. In this case at least the subsequent divisions are in various directions. The same embryo in its relation to the endosperm may be seen in figure *116*.

Citrullus

Several longitudinal series of elevations occur on the placentae and these at an early stage appear merely as undulations on the folds as seen in transverse section. When these elevations have reached a height equal to their diameter at the base or slightly more, the first suggestion of an archesporium is apparent. Up to this time all the cells of the protuberance are of about the same character, staining deeply. The archesporium is of very indefinite character. No enlarged cell adjacent to the epidermis (such as occurred in *Fevillea*) was observed. The sporogenous cell (*fig. 117*) appears in an axial row and is recognizable at first only by its size and the open character of its nucleus. When first distinguishable it is covered by two tabular tapetal cells, sometimes very thin and again of an appearance quite similar to the sporogenous cell itself. There is always one axial row apparent, sometimes one or more parietal rows identical in appearance with the axial one. While in its earliest stages the sporogenous cell may not be easily distinguished from its neighbors, the same does not hold true in its later stages. After a short period has elapsed the spore-mother-cell becomes quite distinct both in size and structural features and there is never more than one cell apparent in that condition in the same ovule.

In the same ovary the early phases of the archesporium may be found about alike in all the ovules, but the rate of subsequent development is dependent to some extent upon the position upon the placenta (see text-figure *5*, *M*), those arising on each placenta nearest its median line having the advantage.

The differentiation of the parts of the ovule does not begin until after the sporogenous cell appears. By the time that the divisions of the spore-mother-cell have been completed the integuments have almost enveloped the nucellus. The proportions of the parts of the ovule are indicated by text-figure *5*, *M*.

After having undergone a period of rest the mother-cell divides to form four potential megaspores. During this period of growth the development of sterile tissue has left the sporogenous cell deep in the nucellus. After the first division of the spore-mother-cell the two daughter-cells again divide, but not simultaneously. The lower one divides first and the division is completed before the division of the upper one (*fig. 118*). The lowermost spore of the four thus formed gives rise to the embryo-sac; the rest disappear.

The development of the embryo-sac takes place by the usual process (*figs. 119–121*). The embryo-sac of eight cells expands in its upper part and the differentiation of the egg-apparatus is begun by the formation of walls about the nuclei and the increase of cytoplasmic substance. This process goes on more slowly at the antipodal end of the sac. The polar nuclei soon come into contact about midway and remain thus for some time (*figs. 121–122 a*). In this case the embryo-sac at the time of fertilization presents about the same appearance as other forms which we have noticed. The egg-apparatus and the antipodals are essentially similar to some of those already studied, though the cytoplasm surrounding the polar nuclei is thin and devoid of starch. The polar nuclei increase in size gradually and probably fuse, though a single endosperm nucleus was not observed at any time.

After fertilization the endosperm nuclei multiply to the number of ten or twelve before the oöspore divides. The cytoplasm becomes distributed in the form of a hollow sac (*fig. 123*) at first, but later assumes a cellular character and becomes solid. As the endosperm begins to expand, the nucellus where in contact with it disintegrates, and the effect of the decomposing influence is apparent for some distance around the embryo-sac, by the modified character of the cell-walls. These stain more readily by haematoxylon and other reagents to which ordinarily they do not respond.

The endosperm becomes cellular at a very early stage, the formation of walls taking place first in its upper portion. Until an advanced stage is reached in the development of the embryo the lower end of the endosperm remains coenocytic, and is terminated by a long coecum which fits into a pocket of cells in the middle of the nucellus (*fig. 126*). The proportion of parts is shown better in an outline figure (*124*). The cells which constitute this "pocket" are much smaller than the others of the nucellus at this stage and by their protoplasmic contents (nucleus, cytoplasm, etc.) seems to be in about the same metabolic condition as those in other parts of the nucellus. These cells appear identical with those which surround the antipodal end of the embryo-sac at the time of fertilization. All the cells of the nucellus are then small and the subsequent enlargement of the others makes these appear smaller by contrast. Why these cells which surround the antipodals should not keep pace in growth with others is not quite clear, nor is it plain why they should not share the fate of others that are broken down by contact with the endosperm. They remain surrounding the extremity of the endosperm until long after the tissue of the nucellus has separated along the median line to the chalaza. The upper and the lower ends of the same mass of endosperm are shown in figures *125* and *126* respectively. The character of the cellular endosperm is entirely similar to that with which we have already become familiar in the preceding forms. The endosperm finally becomes entirely cellular, but while the outer layer consists always of a layer of small cells with dense cytoplasm, the cells of the central part expand to a size many times that indicated in figure *125*, and show the merest trace of cytoplasmic contents. In this condition there is little evidence of its being at all active in the nutrition of the embryo.

The development of the embryo proceeds apparently in about the same way which we have seen in the other forms.

Starting with a single cell which elongates (*fig. 123*), a spherical mass is soon formed which later becomes broadly pyriform (*fig. 125*) with no internal differentiation apparent. If a suspensor is formed at all it is of only transient character. In none of those embryos which had reached a multicellular state was there any evidence of a suspensor.

Cucurbita

The development of the ovules upon the placenta has already been referred to and the different phases of the process are indicated by text-figures *6, A* to *6, D* inclusive. As in the case of *Citrullus*, the origin of the archesporium is obscure. The cells at the apex of the incipient nucellus are all of similar appearance, being of a highly meristematic character, until one larger than the others appears in an axial row separated from the epidermis by two or more cells, presumably the tapetum (*fig. 127*). This cell increases in size while the cells surrounding it segment irregularly. The sporogenous cell assumes a large size in this form and like the others becomes centrally situated in the nucellus (*fig. 128*).

The divisions of the spore-mother-cell appear to be regular. The first division results in the formation of two equivalent cells (*fig. 129*), which again divide to form four potential megaspores. Of these the lowermost produces the embryo-sac (*fig. 129 a*), the others soon showing signs of disorganization. At this stage of development the nucellus consists of a bulbous lower portion surmounted by a narrow prolongation of its tissue which extends upward through the micropyle. By this time the differentiation of the outer portion has reached that stage in which the integuments have enveloped the nucellus and contracted above to form the micropyle.

The divisions of the spore nucleus which now follow produce the embryo-sac in the usual manner. The course of development presents no features worthy of particular mention. After the eight-cell stage is reached the process of differentiation goes on as indicated in *Citrullus*. Figure *131* represents a partially formed embryo-sac in which the synergids and oösphere can be clearly distinguished. Here the polar nuclei are smaller than they appear later and the antipodals are in their prime. The antipodals will be seen to mature much earlier than the other cells of the embryo-sac and have practically disappeared before the others have come to maturity (*fig. 132*).

The embryo-sac of *Cucurbita Pepo* presents a very striking appearance. The endosperm nucleus is possessed of an especially prominent nucleolus and is surrounded by a cytoplasm gorged with starch. The synergids being about two-thirds the length of the embryo-sac are somewhat compressed by the cytoplasm which surrounds their lower portion, which in each case consists of a very thin film enclosing a large vacuole. The nucleus in each case lies just above the vacuole and the upper two-fifths of the cell is hyaline and marked by exceedingly fine striations. In the embryo-sac of another garden variety of *Cucurbita*, the common crook-neck squash (*fig. 137*), the conditions are not the same, though in some points the comparison is hardly fair inasmuch as they are not quite in the same stage of development. The egg-apparatus presents much the same appearance as in the other form of *Cucurbita*, but antipodals are entirely absent. One feature is the entire absence of endosperm, though this may be due to the earlier state of development. The enormous size of the nucleoli in the polar nuclei is here one of the most salient features.

Endosperm develops in *Cucurbita Pepo* much as in other forms, in this family. Figures *134*, *135* and *136* represent its appearance in various stages. The starch disappears early and the mass of cytoplasm becomes distributed peripherally, and twenty-five or thirty nuclei may be formed before the oöspore has completed its first segmentation. The cytoplasm is more dense in the upper than in the lower portion and here also the nuclei are more numerous. The tissue of the nucellus falls before the growing endosperm. The endosperm soon becomes cellular in structure, the formation of walls beginning in the micropylar region (*fig. 136*).

The development of the embryo in *Cucurbita* has not been followed out. Only a few early stages were observed. The development of the embryo appears, however, to proceed slowly, and considerable endosperm may be formed before the first division of the oöspore takes place. The condition represented by figure *138* was found in another garden variety, the Chile squash. In this it is apparent that the first walls to be formed are transverse, but the succeeding ones may be anticlines and probably give rise to a mass of cells similar to those found in the other forms.

Sicyos

About the time that the young ovule begins the turning which finally brings it to the anatropous position the young spore-mother-cell appears below the epidermis at the apex of the nucellus. The same difficulties which hinder the identification of the early archesporium in *Cucurbita* and some other forms are present here. But the presence of two or three tabular cells between the sporogenous cell and the epidermis seems to indicate that the structures in question originate in the usual manner. The tapetal cells undergo repeated divisions tangentially, and by the time the spore-mother-cell is ready for division it has become covered by a long axial row of cells. In fact, the divisions have followed so slowly on the side toward the chalaza, that the sporogenous cell at this stage is much nearer to the chalaza than to the apex of the nucellus. The relative development of the integuments at this period is similar to that observed in other forms.

The spore-mother-cell apparently undergoes the usual divisions in the formation of the megaspore. While these divisions were not observed, nor were the four potential megaspores, the presence of a disintegrating mass of material in the vicinity of the megaspore (*fig. 141*) would be in favor of such an assumption. Furthermore it would appear that the functional megaspore is the lowest one, as in the previous cases.

The two-celled embryo-sac was not observed. But figures *142* and *143* show the four-celled and eight-celled stages respectively. In the latter the prospective function of the different cells can be determined by their position and appearances, although it is far from the mature condition, as may be seen by a comparison of figures *143* and *144*.

In the mature embryo-sac the synergids and oösphere are less vacuolated than in many of the other forms cited and the polar nuclei are not nearly so prominent. No starch was observed in the embryo-sac at any time, though oil was often visible (*fig. 144*). In this embryo-sac, which represents the conditions prevailing near the time of fertilization, antipodals are plainly evident, though apparently not functional. They were not found in any preparations of more advanced material, and so must be, like the others, of ephemeral character.

The formation of the endosperm proceeds as usual. A mass of sac-like form soon appears and elongates rapidly toward the chalaza (*fig. 145*). In this numerous free nuclei are visible at an early stage and they multiply as the mass expands. The character of the cytoplasm is at first open and vacuolated, but later it appears densely granular and homogeneous (*fig. 146*). At this point a large regular central vacuole is formed and the lower portion becomes drawn out into a thin strand which penetrates deeply toward the chalaza. Walls are formed in the upper portion, and half of the endosperm may sometimes appear cellular and half non-cellular (*fig. 147*).

The embryo develops slowly and various stages in its formation were observed. The earliest condition seen presented the appearance shown in figure *145*. Here the first division seems to have been diagonal and the second intercepting this plane and dividing the distal one of the two cells formed by the first division. The subsequent divisions give rise to a pyriform mass (*fig. 146*), and later to the usual structures described for other forms.

Micrampelis

In this form the initial stages in the formation of the archesporium were not observed. By the time, however, that the integuments have become elevated to the top of the nucellus the spore-mother-cell has become quite conspicuous at its center, and is surmounted by an axial row of cells. Here the form and relations of parts of the ovule are similar to those previously considered (*fig. 148*).

It is evident that the spore-mother-cell divides as usual to form potential spores, though the process was not observed in its completeness. The first division takes place and the cell is divided equally (*fig. 149*). In the two-, four- and eight-celled stages we find a perfectly typical development. In each case the center of the embryo-sac is occupied by a large vacuole (*figs. 150–153*) which becomes more or less modified as development proceeds.

In the mature embryo-sac of *Micrampelis* the various organs are quite prominently displayed. The egg-apparatus consists of a conspicuous oösphere and two very bulky synergids, in which there is rather less vacuolization than is evident in most of the forms. The antipodals are more conspicuous here than in any of the preceding species (*fig. 155*). The cytoplasm which surrounds the endosperm nuclei presents a finely vacuolated appearance, but at no time was any starch observed in it. The polar nuclei were not observed to fuse, but they were found in contact at the time just preceding the fertilization. As the embryo begins to form, the endosperm rapidly expands and the cytoplasm assumes a much more dense and compact character in its upper portion, and numerous nuclei are scattered through it (*fig. 156*). As development proceeds, however, its structure becomes more open and it has begun to encroach upon the nucellar tissue (*fig. 157*). Up to this time no walls have been formed between the nuclei, but this condition does not last long. The endosperm early becomes a solid cellular mass (*fig. 158*), in form wedge-shaped and often easily dissected out of the ovule. In this condition the mass makes rapid inroads upon the nucellus, the cells of which show the effect of some disintegrating agent wherever in contact with the endosperm. This disintegration appears in the swelling of the cell-walls and the breaking up of the protoplasm of the cells. The process of cell-formation is initiated in the region near the embryo and the more distant parts are the last to become transformed. The compact character of the upper and peripheral portions of the endosperm is apparent only in the earlier stages; that which is found later being of a much more open nature (*fig. 159*). The expansion of the ovular tissue proceeds rapidly and by the time the endosperm has reached the cellular state (*fig. 158*) the ovule has almost arrived at mature proportions.

The first divisions of the oöspore are transverse (*fig. 156*) and the suspensor consists usually of two cells, the third a terminal cell constituting the proembryo. The cleavages which follow in the proembryo are more or less irregular (*fig. 157 a*). The subsequent divisions give rise to a pyriform mass of cells crowded into the apex of the nucellus. The external differentiation of the embryo proceeds as in the other cases cited, and the origin of the cotyledons is evident before any interval differentiation is apparent (*fig. 159*).

Coccinia

Owing to the difficulty experienced in growing this form the material obtained was but fragmentary. Hence only a glance can be taken at the condition observed in some of the earlier stages.

In this form, which is included in this tribe chiefly on account of the characters of the androecium, the ovules appear upon the placenta as in the case of some of the Cucurbiteae (see text-figure *6*, *E* to *F*). In *Coccinia*, as in some of the previous cases, the character of the tissue in the apex of the young nucellus makes it difficult to identify the archesporium. Only when the development of the megaspore-mother-cell is well advanced, does it appear probable that the origin of the tapetum and the primary sporogenous cell takes place after the usual manner (*fig. 139*). In the cases observed the sporogenous cell appeared situated below an axial row of sterile cells. In this as in previous cases the growth of the ovular organs, integuments, etc., keeps pace with the internal differentiation, and there is no variation from the typical form worthy of mention.

Cyclanthera

In the very young ovules the cells are arranged in confocal series and the archesporial cell is not easily distinguished from the others in size or other features (*fig. 160*). Subsequently the spore-mother-cell appears quite distinct and the tapetal cells to the number of two or more, separate it from the epidermis (*fig. 161*). At this time the initial stage in the formation of the inner integument is visible in the usual form of a slightly elevated ring due in some places to a radial elongation of epidermal cells and in others to periclinal divisions of the hypodermal elements (*fig. 161*). In the subsequent growth of the ovule the sporogenous cell becomes deeply placed in the nucellus. The repeated divisions of the original tapetal cells and the parietal series are evident. The long axial series of cells thus formed is shown in figure *162*.

The spore-mother-cell undergoes the usual divisions and the fertile cell resulting is here also the lowermost of the series (*fig. 163*). The remains of the non-functional megaspores are evident for some time around the distal end of the embryo-sac.

In the development of the embryo-sac from this point on only one early stage was observed. This was the two-cell stage resulting from the division of the megaspore. There is no indication of any irregularity in the process of development. In figure *164* a nearly mature embryo-sac is shown and this differs in no conspicuous way from those previously cited. The egg-apparatus presents the usual appearance with striated and vacuolated synergids. The antipodals are evanescent and apparently devoid of any important function.

The cytoplasm surrounding the polar nuclei presents a rather peculiar appearance (*fig. 164*). The coarser elements of this cytoplasm are distributed in a radiating order around the polar nuclei, which here are seen to be in contact. Bodies with the aspect of vacuoles, whose limiting membrane stains deeply and appears to be relatively thick, are quite conspicuous. That these may be in some sense an accidental feature, due to some process in the preparation of the material, is possible, though this was the only place where they were found, and the same methods were used in the preparation of the material of *Cyclanthera* that were used in other cases. No starch was observed in this or later stages.

After fertilization the endosperm nuclei increase in size and multiply rapidly (*fig. 165*), and the mass as a whole expands in the hollow form.

PART III. DISCUSSION AND CONCLUSIONS

The facts set forth in regard to the organogeny may be summarized briefly as follows: The pistillate flower begins as a lateral outgrowth, the apex of which becomes depressed and then concave. The sepals arise first around the margin of the torus and the petals follow on an inner circle, the members alternating with the outer series. Within the circle of petal-rudiments the carpels arise and become extended upward to form the style. The placenta arises as a longitudinal ridge upon which the ovules are borne laterally, except in the case of *Sicyos*, in which the ovule is pendent from the top of the ovary.

Of those forms whose development has been studied and described above, it appears that *Fevillea* is the most primitive. It is easy to see how all the others may have been derived from such a form. Although, as Müller[64] suggests, the ovary of the Cucurbitaceae may have consisted originally of five carpels, the simplicity of floral construction in *Fevillea*, in both staminate and pistillate flowers, points to the possible course of evolution of the ovary of this family. Without entering at present upon a discussion of the difficult problem of the morphology of the androecium, some facts have been observed in the ontogeny of the ovary which may be discussed in this connection.

In the three tribes, Fevilleae, Melothrieae and Cucurbiteae, the prevailing type of ovary is the tricarpellary form, and various degrees of specialization may be observed culminating in the fruit of *Cucurbita Pepo*. In the members of these tribes we may note varying degrees of development of

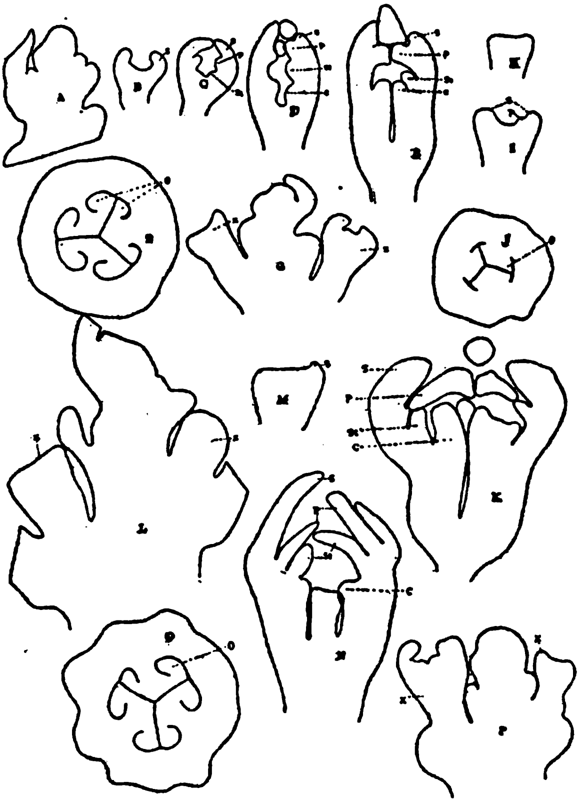

Fig. 1. Development of the gynoecium. *A* to *F*, *Melothria*; *A*, apex of shoot; *B*, *C*, *D*, *E*, stages in the development of the ovary; *F*, transverse section of ovary. *G* to *K*, *Bryonopsis*; *G*, apex of shoot; *H*, *I*, *K*, development of ovary; *J*, section of ovary a little later than *K*. *L* to *O*, *Momordica*; *L*, apex of shoot showing two young pistillate flowers, *x*; *M*, *N*, young pistillate flowers; *O*, section of ovary. *P*, apex of shoot and young pistillate flowers of *Trichosanthes*.

the spongy tissue which fills the locules of the ovary and invests the seeds completely in certain genera (*Cucurbita*, *Citrullus*). While the early stages in the ontogeny of the ovary are very similar so far as observed throughout this family, those changes which mark the appearance of specific and generic characters are soon apparent. The same character may appear later in the ontogeny of the organs in one

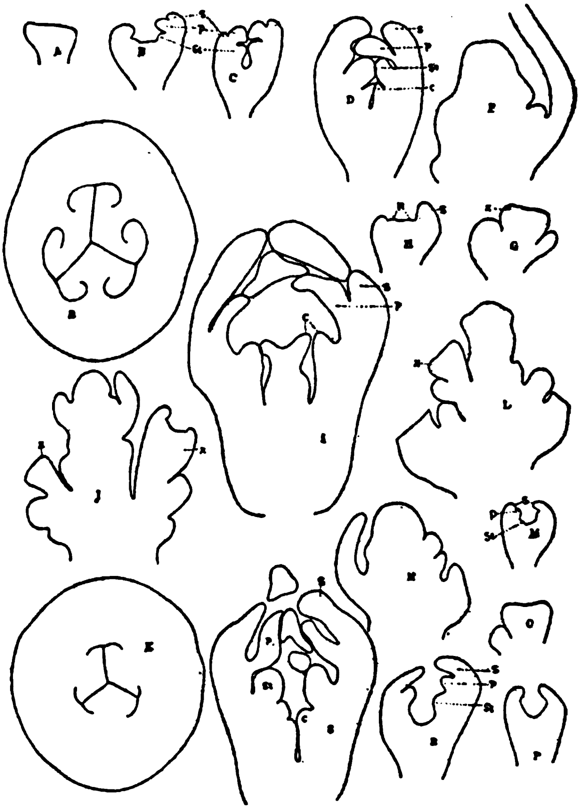

FIG. 2. Development of the gynoecium. *A* to *E*, *Trichosanthes*; *A*, *B*, *C*, *D*, stages in the development of the ovary; *E*, section of ovary. *F* to *I*, *Luffa*; *F*, apex of shoot; *G*, *H*, *I*, development of floral organs. *J*, *K*, *Lagenaria*; *J*, apex with two lateral floral rudiments; *K*, section ot young ovary. *L*, *M*, *Cucumis*; *L*, apex with young flowers; *M*, longitudinal section of young ovary. *N* to *S*, *Citrullus*; *N*, apex; *O*, *P*, *R*, *S*, longitudinal sections of young flowers showing origin of organs.

genus than in another, as for example in the filling of the locules of the ovary by placental tissue. This occurs at an early stage in most of the Cucurbitaceae, even before the formation of the spore-mother-cell. In *Fevillea* the ovules are free in the locules until some time after fertilization, and there is no expression of a tendency toward the development of spongy tissue until much later. The ovary of *Fevillea* is in its earlier stages imperfectly divided into three locules and communication of the interior of the ovary with the exterior is maintained by the imperfect fusion of the ingrowing folds to a much greater degree than is to be found in any such form as *Melothria*, *Cucumis*, *Cucurbita*, *Sicyos* or *Cyclan-*

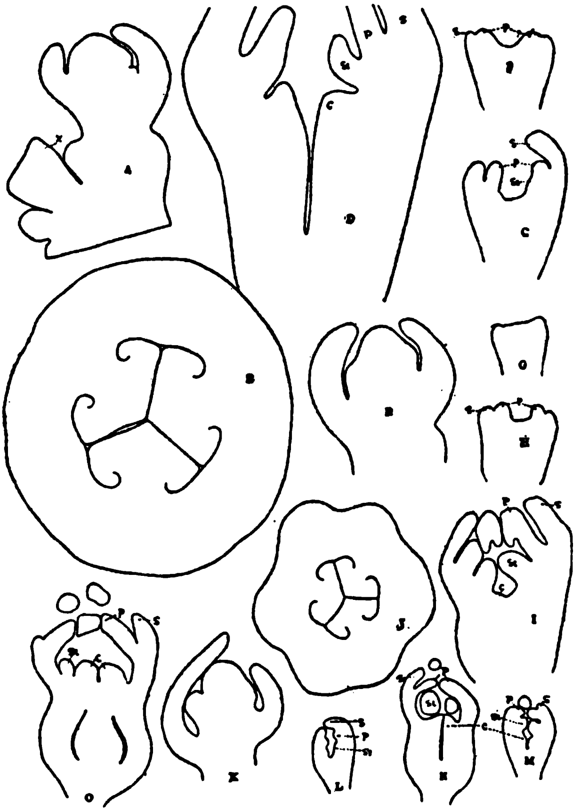

FIG. 3. Development of the gynoecium. *A* to *E*, *Cucurbita Pepo*; *A*, apical region of shoot; *B*, *C*, *D*, floral rudiments in longitudinal section; *E*, transverse section of young ovary. *F* to *J*, similar stages in the development of *Coccinia*. *K* to *O*, *Micrampelis*; *K*, apex of shoot; *L* to *O*, longitudinal sections through young ovary.

thera. This weak development of the septa in the ovary of *Fevillea* is still more significant when we consider the condition found in some related genera (*Alsomitra*, *Zanonia*) in which the ovary, composed of three carpels, is unilocular and open to the exterior at the apex. The development of placental tissue which finally fills the locules in *Fevillea* occurs quite late and never to that degree found in members of the Melothrieae and Cucurbiteae.

Among the Sicyoideae, *Coccinia* represents the condition closely approximating that found in the preceding cases so far as the structure of the ovary is concerned (see text-figure *3*). The carpels unite to form the partitions, and the placentae in the same manner as in the Cucurbiteae. In the case of *Micrampelis*, however, only two carpels are apparent, each of which produces, in our species, but two ovules. The margins of the carpels form two longitudinal elevations which meet at the center and become flattened against one another as in the preceding cases, but instead of a row of ovules upon each flank there appears but one, making four in the entire ovary. While no evidence of more than two carpels has been found in any of the young ovaries of *Micrampelis* examined, nor of more than one ovule on the placental fold in any case, yet it seems probable that the ovary of this form is derived by the reduction of three carpels to two. We find in fact that this form as well as others is subject to some variation, and ovaries are frequently found in the mature state evidently composed of three carpels, inasmuch as they contain three locules and six seeds. But the prevailing number of locules is two. We are reminded of the peculiar apron-like character of the placenta of *Micrampelis* in the development of that organ in *Luffa* and others of the Cucurbiteae, in which there is a downward prolongation of the placenta toward the base of the ovary for a considerable distance beyond its insertion. If in the case of *Luffa* but a single ovule were to arise on each flank of this downward prolongation, we should have a condition quite similar to that noticeable in the early stages of *Micrampelis*. Inasmuch as we find at no stage in the development of the ovary of *Micrampelis* evidence of aborted carpels or ovules, it may be questioned whether in this form we have an ovary derived by reduction from one

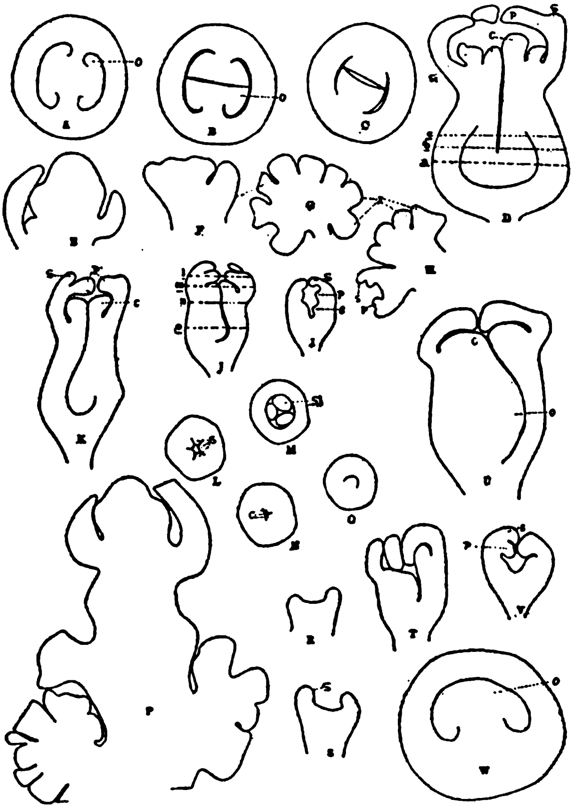

FIG. 4. Development of the gynoecium. *A* to *D*, *Micrampelis*; *A*, *B*, *C*, sections through different regions, *a*, *b*, *c*, of the ovary, *D*. *E* to *O*, *Sicyos*; *E*, apex of shoot; *F*, *G*, *H*, clusters of rudimentary pistillate flowers at different ages; *I* to *K*, longitudinal sections through young ovaries at different stages; *L* to *O*, transverse sections through *J* at the regions indicated by small letters. *P* to *W*, *Cyclanthera*; *P*, apex of shoot; *R* to *V*, longitudinal sections of ovaries at different ages; *W*, transverse section through ovary of about the size indicated by *U*.

having three or a greater number of carpels and a greater number of ovules, but from the fact that the prevailing number of carpels in most of the members of this family is three it seems more reasonable to regard the ovary consisting of two carpels as derived by reduction than as representing a more primitive type. In the development of *Sicyos* there is distinct evidence of such reduction (see text-figure 4). The earlier stages of the development of the gynoecium are marked by the appearance of three equidistant elevations on the torus, which by their position and behavior, must be regarded as incipient carpels. We have here a reduction in the number of functional carpels as shown by the formation of a single placenta, a case therefore quite similar to what might appear should one of the three placental lobes of a form like *Bryonopsis* or *Coccinia* bear a single ovule and the other placental lobes become reduced or obliterated. While the ovules of *Bryonopsis* and *Coccinia* are horizontal, it is quite probable that if they were reduced to one as in the case of *Sicyos* its position would be changed to the vertical.

Cyclanthera in a comparison with *Sicyos* would represent a condition intermediate between that of *Sicyos* and a radially symmetrical form such as *Bryonopsis* or *Fevillea*. If in the ovary of *Cyclanthera explodens* the two rows of ovules should be replaced by a single ovule in vertical position, the condition would be entirely similar to that of *Sicyos*. In the incipiency of the gynoecium three lobes may be recognized, though not so distinctly as in *Sicyos*, and these soon become obliterated in the stigma. It seems quite evident that the ovary of *Cyclanthera explodens* has also been derived from a tricarpellary form. By the abortion of two of the three placental ridges in a form like *Bryonopsis* a condition would result in all essential respects similar to that existing in the ovary of *Cyclanthera explodens*.

The growth of the placenta and the origin of the ovules are matters of interest and are worthy of attention. Evidently the simplest form of placentation is that in which numerous seeds arise on parietal placentae in a unilocular ovary (*Alsomitra*). From this condition it is easy to trace the gradual ingrowth of the edges of the carpels and the development of the various features of placentation, already described to some extent. Text-figures *5* and *6* are designed to represent some of these features.

The condition met with in *Fevillea* shows a step in advance of the parietal placentation in that the carpels have pushed in toward the center of the cavity and have there become flattened by mutual contact. As may be seen, the ovules, borne on rather long funicles, are in the earlier stage horizontal and in this respect the condition evident here is in no essential different from that found in *Melothria*, *Bryonopsis*, *Momordica*, or *Trichosanthes*. In these latter forms the ovules are more numerous on each flank of the placenta. It will be

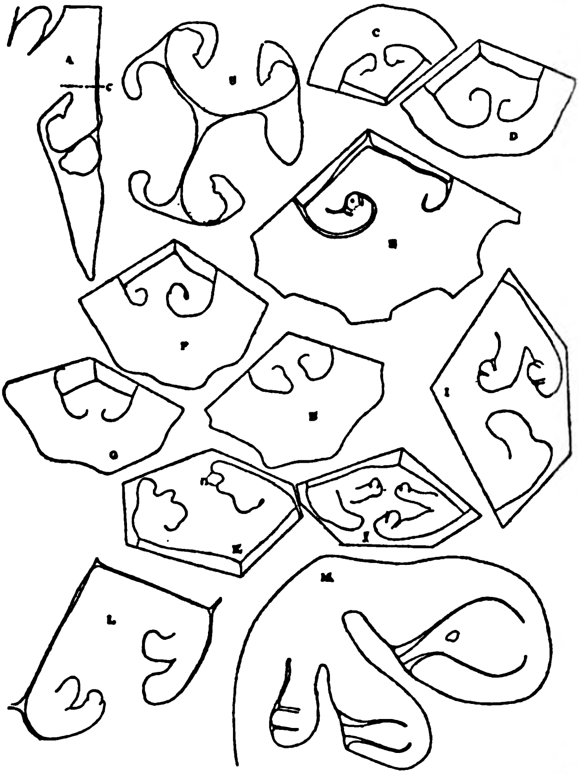

Fig. 5. **Placentation.** *A*, *B*, *Fevillea*. *C*, *Melothria*. *D*, *Bryonopsis*. *E*, *Momordica*. *F*, *Trichosanthes*. *G* to *I*, *Luffa*. *K*, *L*, *Lagenaria*. *M*, *Citrullus*. *J*, *Cucumis*.

noted that in *Luffa* and other members of the Cucurbiteae, and in *Coccinia* and *Melothria*, the early condition of the placentae is uniform, but a differentiation soon appears which distinguishes one from another. Certain outgrowths from the placental flanks mark the point at which the ovules arise. This is shown clearly in the case of *Luffa*, and also in *Lagenaria* and *Cucurbita*. In *Luffa* and *Cucumis* two ovules arise on each flank, but in *Lagenaria*, *Citrullus*, and *Cucurbita* the number varies from two to several.

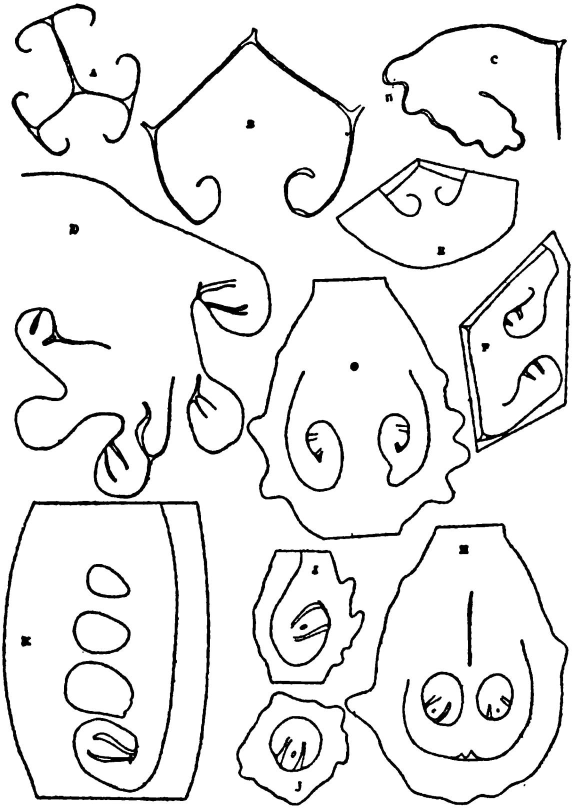

Fig. 6. Placentation. *A* to *D*, *Cucurbita Pepo*, **showing origin of ovules and their comparative development on the same placenta,** *D*. *E*, *F*, *Coccinia*. *G*, *H*, *Micrampelis*. *I*, *J*, *Sicyos*. *K*, *Cyclanthera*.

As to the nature of the inferior ovary in the Cucurbitaceae, Naudin[66] (1855) expressed the view that it was always wholly or in part invaginated in the tissue of the peduncle, and that the calyx is generally free from adherence to it. In support of this position he cites cases where the calyx-lobes return to foliar conditions with distinct laminae and petioles.

This view of the nature of the inferior ovary was not new with Naudin. Schleiden[76] (1846) after investigations on *Rosa*, *Leucojum*, *Godetia*, *Epipactis* and some other plants, concluded that the ovaries were formed entirely of the floral axis; furthermore that the carpels were only the upper part of the ovary and that their tips run up to form the style and stigma. According to his view the conception of the inferior ovary as a fusion of the carpels with calyx and corolla was an assumption unnecessary if not untenable. He points out that in the development of the flower in *Canna exigua* and other plants the invagination at the apex of the axis, which is the beginning of the formation of the ovary, takes place before there is any trace of the appearance of the perianth, and further that in many cases the calyx and corolla are entirely separate and stand free from the ovary. And so the ovary, pistil and stigma represent modifications of no particular organs but are sometimes of axial, sometimes of foliar character.

Goebel,[30] however, in 1886, studied the development of *Pyrus Malus* and shows that the carpellary leaves are laid down in the young flower, but that the subsequent intercalary growth of the zone on which they are inserted produces an ovary "lined inside by the insertions of the carpels." This zone in a perigynous flower is but slightly widened. The ovary of *Pyrus* Schleiden did not regard as truly inferior but as representing a fusion of carpels and floral axis. Goebel, however, regards it as the product of the growth of the bases of the carpels and the zone upon which they are inserted. All investigations upon the development of inferior ovaries, he concludes, must reckon with the question as to how much of the area of the base of the flower is occupied by the incipient carpels. In the younger stages, which show the first laying down of the carpels, particularly in the Umbelliferae and the Compositae, the carpels cover the whole of the inside of the depression, and sometimes the gynoecium takes up the whole of the vegetative point. In his words then it may be summed up: "die Placentation im überständigen und unterständigen Fruchtknoten eine ganz obereinstimmende, eine Thatsache, die auf eine übereinstimmende Betheiligung der Fruchtblätter in beiden Fällen hinweist."

B. Schaefer[78] (1890) traced the development of the ovary in numerous plants, among which were the Campanulaceae. The particular representative taken from that family was *Phyteuma nigrum*, in which he finds that the carpellary "Anlagen" are laid down while the terminal concavity is yet quite shallow and appear as two opposite elevations on a slightly elevated ring extending to the base of the cavity. Transverse divisions of the first two or three periblem layers of cells at the sides of the base of the concavity elevate the overlying tissues and so deepen the depression. He says that the tissue which forms the covering of the ovarian cavity appears as an outgrowth of the parietal placental folds. In conclusion he says that the placentation in inferior ovaries, which he investigated in the Compositae, Onagraceae and Campanulaceae, is wholly in accord with that found in superior ovaries. He carefully points out the course of development in the different forms and maintains that the carpels form a lining of the ovarian cavity, their backs being fused with axial tissue. After quoting from Goebel's work, above cited, he says: "So befand sich die Entwickelungsgeschichte in schroffem Gegensatz zur Morphologie, welche auf Grund theils von vergleichenden untersuchungen, theils von Missbildungen zu der Annahme gekommen war, dass die Fruchtblätter sich auch an der Bildung des Unterständigen Fruchtknotens betheiligen, indem sie, mit ihren Rückentheilen an die Axe gebunden, die Innenseite der Höhlung auskleiden."

The facts observed in connection with the development of the ovary in the Cucurbitaceae, apparently support the contention of Schleiden that the placentation is mainly of an axial character and that the carpels contribute principally the upper portion of the ovary and the style. Here also we are in accord with the conclusions of Lestiboudois,[52] who studied the process of development in *Cucumis* and *Bryonia*. He states that the carpels appear as projections which elongate and finally close the cavity before the formation of the ovules.

Furthermore, that the carpellary "mamelons" are the same in appearance as those which represent the sepals, petals and stamens (staminodia). This appears most distinctly in the case of *Fevillea* (*pl. 58*, *fig. 6*), but in all the other cases it is to some extent apparent and in some more than in others. After the first appearance of the carpels as minute lobes on the peripheral surface of the torus, there is in every case an accelerated growth of the periblem layers situated just below the insertion of the carpels, that is, toward the center of the torus. The growth of the ovary takes place then mainly below the insertions of the carpels, the cells around the bottom of the cavity retaining for some time a distinctly meristematic character. The bottom of the original concavity which is indicated by the termination of the stylar canal is in some cases (*Luffa*) far removed from the lower end of the placenta in its later stages, the growth having occurred mainly in the lower portion of the ovary. There is no evidence of the fusion of the backs of carpels, either with axial tissue or with portions of the perianth, and such an assumption here seems unnecessary.

Text-figures *1–4* inclusive show the course of ontogenetic development in the gynoecium as already described at length in the treatment of the organogeny. The zone of growth just below the insertion of the carpels is, in every case, clearly apparent. In certain cases, as in *Fevillea*, the placenta is evidently foliar in origin (text-figure *5*, *A*), and possibly in *Sicyos* (text-figure *6*, *I*), but in all the others examined it arises not from carpellary tissue but by a thickening, in certain definite regions, of the ovary wall.

The influence of the carpels is sometimes manifest in an earlier development of the ovules in their region than on parts of the placenta more remote, as might be expected where the function of seed-bearing has been transferred gradually from sporophylls to axial tissue, though this condition may be due to better nutrition. Too much emphasis can hardly be laid upon the peculiar character of the placenta in this family. We have noted the different forms which the placenta assumes and the varied structure of the ovary, and all the facts observed point to the placenta as a center of variation. It is here that we find evidence of the gradual assumption of the function of reproduction by tissues of an axial nature and a corresponding decrease in the extent to which foliar tissue is concerned in this work. This indicates a certain degree of plasticity in the axial tissue, which is further expressed in the multiplying of ovular series on the placental folds, to which attention has been called in the comparison of forms like *Melothria*, *Cucumis* and *Cucurbita*. It is apparent here that we have a condition of morphological independence in which new powers of variation are acquired, which have been utilized in the various modifications of placenta and ovary already pointed out. While it is true that the number of placental folds generally corresponds to the number of carpellary rudiments, this is not always so (*Sicyos*); and in those cases in which the number of placental ridges is usually three, four or five may sometimes be found (*Cucurbita Pepo*); and where two is the rule three may occur, etc. In other words a condition of variability exists which is more or less restricted by hereditary tendencies (Ganong[26]).

The more important features of the ovule and embryo-sac of the various species examined have been described. A comparison of these facts shows a considerable degree of uniformity in the development of these structures between the most widely varying members of the family. The ovule in all cases is anatropous and the relative importance, in point of size, of the nucellus and the integuments is quite constant in all the species investigated. The ovules of the Cucurbitaceae differ from those of most other Sympetalae in some respects, as already pointed out in the discussion of *Fevillea*. The nucellus in this family is much more prominent than in other members of the sympetalous group, and differs from these further in the fact that two integuments are always present though the inner one seldom attains a thickness of more than two cell-layers. The outer integument is always conspicuous and the walls of certain layers of its cells become peculiarly thickened and sculptured. It will be noted that in *Fevillea* we have the least departure from the typical sympetalous condition in the relative size of outer integument and nucellus, although here the inner integument finds its greatest degree of development, which may partly be due to its formation in an open ovary, where it is free from the pressure of the surrounding tissue. If the facts in the development of the gynoecium will justify our conclusion that *Fevillea* is a more or less primitive form in this family, it would appear that the peculiar characters of the ovule in the Cucurbitaceae are not primitive but specialized.

In the formation of the archesporium, evidence points to a single archesporial cell as the forerunner of the sporogenous tissue. While in some cases the definite hypodermal archesporial cell was difficult to identify, the character of the hypodermal mass concerned did not seem to justify the distinction of a multicellular archesporium. It appears, therefore, that the members of the Cucurbitaceae conform to the usual type in this respect, though in some cases expressing apparently no very distant departure from the presumably primitive condition of an archesporial complex.

In one point in the subsequent development the species herein described present features much at variance with the corresponding stages in other Sympetalae. Here we find no tendency toward a reduction of the tapetal or parietal (Coulter and Chamberlain[15]) cells. These are always multiplied to the number of ten or twelve before the embryo-sac is formed. If the suppression of the tapetum is to be regarded as a specialized condition, for which there seems some reason, we find here another primitive character, though we should not lose sight of the fact that such conditions exist in many of the lower angiosperms.

In the division of the primary sporogenous cell four megaspores are usually formed, and the condition in this family is therefore in harmony with the almost universal habit in the Sympetalae. In all the cases where it was observed the tetrad was a straight row of cells of which it was always the one at the chalazal end of the series which became functional, the only apparent reason for the selection of this cell being its more advantageous situation with reference to the source of nutritive materials which come through the chalaza, an idea which Koernicke has also expressed.[50] In all cases the spore enlarges considerably and then proceeds to the regular series of divisions, which usually gives rise to but eight nuclei from which the egg-apparatus and other structures are differentiated. Very few mitoses were observed in all the preparations examined and no generalizations can be made concerning conditions upon which such facts are supposed to throw light. Where the divisions were observed they were simultaneous within the same sac, and there was no evidence of the most evanescent kind of a cell-plate. In the formation of the egg-apparatus and the development of its particular features we recognize those characters so common among the dicotyledons and the Sympetalae in particular. In fact in all essential features the embryo-sac is similar to many others, from various sources and cycles of affinity. The polar nuclei in many cases have been observed to unite before any evidence of fertilization was apparent. While neither of the polar nuclei was observed to lie in contact with the egg-cell their position was uniformly close to it. The lower of the polar nuclei always migrates to the vicinity of the egg-apparatus, where it unites with the upper one; but no migration of the fusion nucleus occurs as observed by Ikeda[44] in *Tricyrtis hirta.*

Among the Sympetalae there is a tendency toward the retention of the antipodals, and even in some cases toward the formation of tissue by their proliferation. But such is not the case here, where it has been shown that the antipodals are never of more than transient duration. There is absolutely no evidence that these cells in the Cucurbitaceae are at all concerned in any of the formative or nutritive work carried on in the embryo-sac. In the development of some of the forms here considered the failure of the antipodals to develop is accompanied by a cessation of growth in that region not only in the embryo-sac but also in the cells of the nucellus which immediately surround them; so that in much later stages when the cells of the nucellus have expanded to many times their former size, the mass of cells referred to forms a sort of pocket into which is inserted the end of the vermiform prolongation of the endosperm (*Citrullus*, *Apodanthera*). Not only is this true, but a slight thickening of the walls of these cells takes place and an appearance, as if cutinized, is one of the more conspicuous features. Other cases of the retardation of the antipodal region have already been observed in *Typha*, *Sagittaria*, *Oenothera* and other genera.

The process of fertilization and the origin of the embryo is still an open question in the Cucurbitaceae, except for the case of mesogamy cited by Longo in *Cucurbita Pepo*.* In the many preparations that were made and studied not one showed this phase with sufficient clearness to justify any conclusions. There is evidence, however, that the processes of fertilization and embryo-sac development are normal.† In the case of every species studied, except *Coccinia*, the presence of the pollen-tube was detected in the micropyle and in many cases it had even penetrated through the tissue of nucellus into the embryo-sac. In the case of *Cucurbita Pepo* the end of the pollen-tube was found in the micropyle before it had reached the embryo-sac. In its extreme end appeared the large vegetative nucleus and just posterior to this two smaller ones, presumably the generative nuclei (*fig. 133*).

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*Rend. R. Accad. Lincei, 10: 168–172. 1901.

† Massart's contribution to this subject was not accessible and reference to it has of necessity been omitted.

But the actual conjugation of the oöspore with the male generative nucleus was not observed, nor could it be said that one of the synergids was not fertilized, though this seems improbable.

The pollen-tube in this family presents some interesting peculiarities. In most of the cases studied it proceeds straight through the micropyle to the embryo-sac. But in *Cyclanthera* and *Cucumis* the pollen-tube becomes dilated in the neck of the nucellus which extends through the micropyle and the surrounding cells are broken down to make way for it. This dilation is carried to an extreme in *Cucurbita Pepo*, which has recently been described by Longo.[54] In this case the tube branches and ramifies in different directions through the tissue of the integuments. The writer had hoped to treat more fully the subject of fertilization and the behavior of the pollen-tube in this paper, but the failure thus far to secure the best of material for such a study has rendered it expedient to leave this subject for a later contribution.

In the Cucurbitaceae great interest attaches to the behavior of the endosperm. The forms which this tissue assumes have already been described. As a rule the divisions of the endosperm nucleus occur before the first cleavage of the oöspore. Fusion of the polar nuclei must take place about the time of fertilization; in the cases where it was definitely observed it took place slightly before the appearance of the pollen-tube, and where the complete fusion was not apparent, numerous endosperm nuclei were to be seen while the embryo-sac was still undivided.

The appearance of starch in the embryo-sac at the time of fertilization is significant. It is not of general occurrence, but was found only in *Apodanthera*, *Bryonopsis*, *Luffa*, *Trichosanthes* and *Cucurbita*. Inasmuch, however, as starch is frequently of very transient duration it might have been overlooked in others. It is quickly formed as the embryo-sac approaches maturity and reaches its maximum before the appearance of the pollen-tube. No starch-grains were found in any case after the first division of the oöspore. In the case of *Luffa*, *Trichosanthes* and *Bryonopsis* it will be observed that the starch appears before the fusion of the polar nuclei, though in the case of *Apodanthera* the fusion takes place before the formation of the starch. In *Cucurbita* the fusion-nucleus is seen in the midst of the starchy cytoplasm.

The source of this starch is a matter of much interest. Schleiden[75] states that the starch is brought to the ovule of *Cucurbita* by the pollen-tube, but here we find starch in the embryo-sac before the pollen-tube appears. D'Hubert[19] describes a condition in *Phyllocactus* in which starch is formed first in the antipodals and later disappears from these and accumulates in the free cytoplasm of the embryo-sac. Lloyd[53] reports an abundance of starch in *Galium* surrounding the polar nuclei and also in the antipodal cells. He finds it also in *Diodia* and *Houstonia* to some extent, though in the former it appears first in the antipodals and later in the endosperm. In either case it appears to be wanting until after fertilization.

It will be noted that in *Cucurbita* and the other cases cited the polar nuclei or the fusion-nucleus by their size and chromatic features exhibit a high degree of metabolic activity. The antipodals in some cases are prominent (*Trichosanthes*) and in others (*Cucurbita*, *Apodanthera*, *Luffa* and *Bryonopsis*) either partially disorganized or merely vestigial. Hence it is evident that the antipodals are not physiologically active at this stage. In those cases in which the fixation was accomplished by osmic acid mixtures, the presence of much oil was apparent in the tissue of the nucellus immediately surrounding the embryo-sac (*Cucumis*, *fig. 84*). The quantity of oil is greatest nearest the embryo-sac. The evidence at hand indicates that the oil is absorbed from these cells by the embryo-sac and becomes transformed into starch in the cytoplasm surrounding the polar nuclei.

The physiological equivalence of fats and carbohydrates is a fact well known. Pfeffer[70] points out that, during the germination of the oily seed of the cucumber, glucose is formed abundantly, and oil is formed from glucose in the ripening seed of *Ricinus*, but from starch in the endosperm of *Paeonia*. In the germination of the cocoanut starch is formed abundantly (Kirkwood and Gies[49]) from the reserve fats of the endosperm and this process is intra-cellular within the cotyledon. The absorption of fats then takes place, probably in an emulsified condition, through the cell-walls, and starch is formed from the products of their decomposition. It is not easy to determine, in a structure so small as an embryo-sac, the presence of an emulsifying or adipolytic ferment by an experimental process, but it seems probable that such may occur. However, in the case of the cocoanut no such agent has been detected.

It is evident that starch serves an important nutritive function in the subsequent growth of the endosperm. Its very transient character, and the immediate expansion of the endosperm as a whole, indicate that it is consumed in the process. It can hardly be regarded as a nutritive medium for the embryo directly, inasmuch as the oöspore exhibits very little growth until after the elongation of the endosperm, the multiplication of its nuclei and the disappearance of the starch. The development of the embryo begins only after the endosperm has displaced part of the tissue of the nucellus.

The general features of the growth and development of the endosperm in the Cucurbitaceae have been known for some time. Mirbel[59] (1815) observed that the perisperm in seeds of *Cucurbita* was very thin, that the cotyledons were large and broad. Again, in 1829,[60] he discusses the morphology of *Cucumis Anguria* and *C. leucantha*, and figures an ovule and the structures it contains after fertilization. In this particular case the endosperm occupies a large space in the nucellus and in form was ovoid with a tube-like prolongation at its lower end. The embryo at this stage he represented as narrow, pyriform, and about one-sixth the length of the endosperm.

Schleiden,[76] in the second edition of his *Grundzüge der wissenschaftliche Botanik*, describes an ovule of *Cucurbita Pepo* after fertilization and represents the embryo-sac as extending from micropyle to chalaza. In another work[75] (1845) he states that the embryo-sac shows a chalaza-ward extension at about the time when the pollen-tube begins its distension in the micropyle. He further states that when the ovary has reached a length of about fifty millimeters the endosperm has begun to show a cellular structure. Garreau[27] (1849) studied *Momordica Elaterium* and *Cucumis sativus* and shows that in the former case the endosperm had replaced about half the tissue of the nucellus while the embryo was still only a spherical, undifferentiated mass of cells. Although he misunderstood some of the structures which he saw, he correctly represented the elongated mass of endosperm of *Cucumis* narrowed at its lower end. In this case the endosperm has begun to show a cellular structure in its upper portion while the embryo was still a pyriform mass of cells. Hofmeister[41] (1849) went further in his study of the endosperm of *Ecballium* (*Momordica*) *Elaterium*. He observed that the endosperm rapidly displaced the nucellus and that the embryo in turn displaced the endosperm. He further represented the vacuolated granular character of the endosperm cells and expresses the opinion that the process of development in the ovule of *Ecballium* was repeated in those of other members of the Cucurbitaceae.

The facts obtained in this study relative to the behavior of the endosperm have been recorded in each special case, and a comparison of the results will show that there is some degree of uniformity in the growth and development of the endosperm in the different species. It first expands into a sac-like body in the periphery of which are numerous free nuclei formed before the first division of the fertilized egg. The coenocytic condition is retained for some time and is gradually replaced by a cellular structure, first in the micropylar region. The expansion of the endosperm is rapid and always first in the direction of the chalaza. The most rapid expansion takes place usually in the coenocytic condition. The tissue of the nucellus is rapidly disorganized wherever the endosperm comes into contact with it. There seems to be no doubt that the nucellus is digested by ferments secreted by the endosperm and that the embryo in its early stages is nourished by the products of this digestion, though not directly. Although anatomical evidence only is at hand on this question, the facts observed were all in harmony with the above conclusion. The endosperm grows at first at the expense of the embryo by utilizing the materials which it obtains for its own development, but when the embryo at a later time begins its growth it does not digest the endosperm, but apparently absorbs the material supplied by it. That the endosperm is only temporarily functional in this way is indicated by its appearance in those stages of embryonic development which follow the differentiation of cotyledons. At about this time the ovule has almost assumed the proportions of a ripe seed and the nucellus is able to offer no resistance to the growth of the embryo or to the flow of those nutritive substances which enter through the chalaza. The endosperm very early replaces most of the nucellar tissue and before the embryo is far along in its growth there is little of it left. The endosperm loses most of those plasmatic characters which indicate an active metabolism, and becomes of very thin and watery consistency.

That endosperm sometimes acts as a digestive medium in absorbing the tissue of the nucellus has been shown by Johnson,[47] in the case of certain species of the Piperaceae. Haustorial extensions of the endosperm are more or less common in many families among the Sympetalae. Balicka-Iwanowska[4] found in the Campanulaceae haustoria developed from the endosperm which penetrated the integuments of the ovule. From these and other observations the generalization was made that such haustoria were formed only in ovules with thick integuments. Other investigations in the Campanulaceae have been conducted by Hegelmaier.[39] He found that the endosperm of *Specularia* extends toward the chalaza in a string-like mass which may sometimes become divided by walls transversely and sometimes longitudinally. Other investigations on the Lobeliaceae and the Stylidiaceae reveal haustorial appendages of the embryo-sac which serve a nutritive function. But such structures are not confined to the Sympetalae, for Miss Benson[5] has found in several members of the Amentiferae a vermiform extension of the embryo-sac which reaches toward the chalaza.

The form assumed by the embryo is remarkably uniform from the first. Usually two or three transverse divisions of the oöspore result in the formation of a proembryo and a rudimentary suspensor which lasts but a short time. Subsequent divisions proceed with no perceptible regularity until a globular or pyriform mass is formed. After this stage the embryo becomes broadened distally and the cotyledons appear. At the same time there is an internal marking off of root-cap and dermatogen. Subsequent growth develops the cotyledons and the growing point of the stem is organized very late.

In many of the sympetalous families the forms of the embryo are quite different from those in the Cucurbitaceae. In the Campanulaceae Tulasne[33] found that the oöspore of *Campanula* elongates to ten or twelve times its diameter, and then forms near its outer end two or three transverse walls, the terminal cell being the proembryo. In the Rubiaceae and in the Globulariaceae an extensive suspensor is developed. But the different degrees of development which the suspensor may reach is so varied throughout the angiosperms that this feature is of little value as a means of determining relationships.

As to the systematic position of the Cucurbitaceae, the facts at hand will hardly justify any sweeping conclusions. Too little is yet known of the exact course of intra-seminal development in this and in other families supposed to be closely related. Of the eighty or more genera of this family but a few have been carefully studied, and while these are quite representative and the results uniform, still it would no doubt be advantageous to know the conditions existing in some other members of the Fevilleae, *e. g.*, *Alsomitra* and *Zanonia*. This is desirable from the fact that *Fevillea* itself presents conditions less at variance with those found in others of the

Sympetalae, not only in the form and structure of its ovule but also in a certain character of its embryo-sac, viz., the increase in the number of antipodals. But in most points the differences between the Cucurbitaceae and other sympetalous families are more striking than the similarities, and include the form and structure of the ovule, the presence of a distinct tapetum and the ephemeral character of the antipodals.

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KEY TO THE LETTERING OF TEXT-FIGURES AND PLATES

c, carpel.
n, nucellus.
o, placenta.
p, petal.
s, sepal.
st, staminodium.
sl, stigmatic lobe.
x, pistillate flower.
ii, inner integument.
oi, outer integument.
h, haustorium.
pt, pollen-tube.
en, endosperm.

Explanation of Plates 58–69

Fevillea cordifolia (PLATES 58 AND 59).

1. Apex of shoot, showing origin of pistillate flowers. × 60.
2. Cellular structure of the apex. × 184.
3. Rudiment of a pistillate flower. × 184.
4. Later stage of same, showing origin of sepals. × 184.
5. Ditto, showing origin of petals.
6. Outline sketch of later stage, showing origin of carpels and staminodia. × 60.
7. Transverse section through young ovary, showing origin of the placentae. × 144.
8. Placenta and ovule. × 60.
9. Archesporial cell. × 440.
10. Showing condition of nucellus. × 184.
11. Primary sporogenous cell and tapetum. × 440.
12. Spore-mother-cell deep in tissue of nucellus. × 440.
13. Form of ovule, longitudinal section. × 60.
14. Megaspore-mother-cell. Metaphase of first division. × 920.
15. Ditto, after first division. × 920.
16. Four megaspores; lowermost one functional. × 920.
17. Embryo-sac of four cells. × 440.
18. Embryo-sac approaching maturity. × 440.
19. Definitive embryo-sac. × 480.
20. Embryo-sac and upper part of endosperm. × 440.
21. Portion of nucellus showing extent of endosperm. × 40.
22. Embryo and endosperm. × 440.

23. Embryo and endosperm. × 184. Endosperm somewhat disintegrated.

24. Embryo. × 440.

Melothria pendula (PLATES 59 AND 60).

25. Megaspore-mother-cell. Origin of inner integuments, *ii*. × 440.

26. Four-celled embryo-sac. × 440.

27. Embryo-sac near maturity. × 440.

28. Embryo and endosperm. × 440.

29. Ditto, slightly later. × 440.

30. Embryo. × 440.

31. Embryo of 14 to 16 cells. × 440.

32–34. Embryos of various stages. Magnified 440, 324 and 184 times respectively.

Apodanthera undulata (PLATE 60).

35. Definitive embryo-sac. × 440.

36. Endosperm showing starch. × 440.

37–38. Embryos. × 440.

39. Apex of nucellus, pollen-tube, embryo and endosperm. Haustorial extension of endosperm. × 184.

40. Embryo of 39, enlarged. × 440.

41. Anatomical relations of nucellus, embryo and endosperm. × 30.

42. Apical region of radicle of young embryo, showing some differentiation of root-cap and dermatogen. × 184.

43. Same embryo showing region, from which stem apex is formed. × 184.

43*a*. Schematic representation of same embryo.

Bryonopsis laciniosa erythrocarpa (PLATE 61).

44. Apex of nucellus showing primary sporogenous cell. × 312.

45. Ditto, later. × 312.

46. Megaspores, functional one longest. × 312.

47. Two-celled embryo-sac. × 440.

48. Embryo-sac of eight cells before migration of polar nuclei. × 440.

49. Embryo-sac near definitive stage. Starch-grains abundant. × 440.

50. Embryo-sac after fertilization. Oöspore and endosperm with scattered starch-grains. × 440.

51. Embryo and contiguous endosperm. × 440.

Trichosanthes Anguina (PLATE 61).

52. Apex of nucellus showing archesporial cell. × 440.

53. Primary sporogenous cell and tapetal layers. × 440.

54. Concluding stage in second division of the sporogenous cell. Divisions apparently suppressed in the other cell. × 440.

55. Megaspore. Non-functional ones represented by black mass. × 440.

56. Embryo-sac showing starch content. × 440.

57. Two-celled embryo and upper portion of endosperm. × 440.

58. Four-celled embryo. × 440.

59. Outline sketch showing proportions of nucellus, embryo and endosperm. × 40.
60. Portion of endosperm from same. × 440.
61. Embryo from 59. × 184.
62. Embryo and endosperm. × 40.

Momordica Charantia (PLATES 61 AND 62).

63. Young ovule showing megaspore-mother-cell. × 184.
64. Megaspore-mother-cell. × 440.
65. Embryo-sac of two cells.
66, 66*a*. Different sections through the same embryo-sac. × 440.
67. Pollen-tube, embryo, and endosperm. × 440.
68. Embryo and endosperm. × 184.
69. Embryo, pollen-tube and endosperm. × 36.
70. Embryo, cellular endosperm. × 440.
71. Showing relative proportions of embryo, endosperm and ovular tissue. × 36.

Luffa acutangula (PLATES 62 AND 63).

72, 73, 74. Megaspore-mother-cells at different ages. × 440.
75. Megaspores, functional one largest. × 440.
76. Two-celled embryo-sac. × 440.
77. Four-celled embryo-sac. × 440.
78. Eight-celled embryo-sac. × 440.
79. Embryo-sac near maturity. × 440.
80. Oöspore and endosperm containing scattered starch-grains. Disintegrating nucellar cells. × 440.
81. First division of oöspore completed.

Cucumis myriocarpus (PLATES 63 AND 64).

82. Primary sporogenous cell and tapetum. × 440.
83. Telophases of the second division of the megaspore-mother-cell. × 440.
84. Embryo-sac near the definitive stage. × 440.
85. Representing embryo of three cells. × 440.
86. Similar to 85. × 440.
87. Young embryo and endosperm. × 440.
88. Embryo, endosperm and pollen-tube. Showing effect of endosperm on cells of nucellus. × 184.
89. Embryo of same. × 440.
90. Embryo. × 440.
91. Embryo, endosperm and nucellus. × 40.
92. Apical region of radical end of embryo from 91. × 440.
93. Portion of endosperm; the large cells are at the center of the mass, the small ones at the periphery. × 440.

Lagenaria Lagenaria (PLATE 64).

94. Apex of young ovule before differentiation of archesporium. × 440.
95. Sporogenous cell and tapetum. × 114.

96. After first division of megaspore-mother-cell. × 440.

97. Four megaspores. × 440.

98. Mitoses of the embryo-sac nuclei preceding eight-cell stage. × 440.

99–100. Stages approaching definitive embryo-sac. Showing aggregation of starch. × 440.

101. Illustrating first division of oöspore and young endosperm. × 440.

102. Embryo of five or six cells. × 440.

103. Young embryo and cellular endosperm. × 440.

104. Endosperm, embryo and part of nucellus. × 184.

105. Diagrammatic sketch showing relative proportions of embryo, endosperm, and nucellus. × 40.

106. Same embryo with upper part of endosperm. × 184.

107. Older embryo. × 184.

Benincasa hispida (PLATE 65).

108. Apex of very young ovule before formation of archesporium. × 440.

109. Megaspore-mother-cell and tapetum. × 440.

110. Four-celled embryo-sac. × 440.

111. Eight-celled embryo-sac. × 440.

112. Nearly mature embryo-sac. × 440.

113. Oöspore and endosperm. × 440.

114. Ditto, slightly later. × 440.

115. Showing lines of cleavage in embryo. × 440.

116. Endosperm and disintegrating nucellus. × 440.

Citrullus Citrullus (PLATES 65 AND 66).

117. Apex of nucellus; primary sporogenous cell and tapetum. × 312.

118. Process of formation of megaspores. × 440.

119–121. Two, four, and eight-cell stages in embryo-sac formation. × 440.

121–122*a*. Different aspects of the embryo-sac near time of maturity. Oöspore omitted from 122*a*. × 440.

123. Oöspore and growing endosperm. × 440.

124. Diagram of embryo, endosperm and nucellus; *V*, representing "pocket" of cells around end of haustorium. × 40.

125. Embryo and upper part of endosperm indicated in 124. × 440.

126. Showing terminal portion of haustorium and structure of "pocket." × 312.

Cucurbita Pepo (PLATES 66 AND 67).

127. Primary sporogenous cell and tapetum (?). × 440.

128. Same at later stage (megaspore-mother-cell). × 440.

129. After first division of megaspore-mother-cell. × 440.

129*a*. The four megaspores. × 440.

130. Four-celled embryo-sac. × 440.

131. Embryo-sac of eight cells. Early stages in differentiation of parts. × 440.

132. Definitive embryo-sac containing starch. Antipodals vestigial. × 440.

133. Apex of pollen-tube as it appears in the micropyle. × 440.

134. Oöspore and young endosperm. × 440.

135. Showing relative extent of endosperm in the same case as 134. × 160.

136. Showing form and structure of the endosperm. × 312.

137. Embryo-sac (crook-neck squash) near maturity. × 440.

138. Young embryo (Chile squash). × 440.

Coccinia cordifolia (PLATE 67).

139. Megaspore-mother-cell and tapetum. × 440.

140. Four-celled embryo-sac. × 440.

Sicyos angulata (PLATE 67).

141. Nucellus and inner integuments. Megaspore-mother-cell after first division. × 184.

142. Embryo-sac of four cells. × 440.

143. Embryo-sac of eight cells. × 440.

144. Embryo-sac, almost mature. × 480.

145. Young embryo and endosperm. × 440.

146. Pollen-tube, embryo and endosperm. × 184.

147. Showing progress of endosperm formation. × 312.

Micrampelis lobata (PLATES 68 AND 69).

148. Nucellus and spore-mother-cell. × 184.

149. Telophase of first division of spore-mother-cell. × 440.

150–151. Two-celled embryo-sacs of slightly different ages. × 440.

152. Embryo-sac of four cells. × 440.

153. Embryo-sac of eight cells. × 312.

154. Showing process of differentiation in the embryo-sac of eight cells. × 440.

155. Embryo-sac near maturity.

156. Young embryo and endosperm. Showing also remnant of a synergid and the pollen tube. × 312.

157. Slightly later stage than 156. Embryo of about ten cells. × 312.

158. Embryo and endosperm. Characteristic appearance of endosperm in the early stages of embryonic development. × 120.

159. Later stage in the development of embryo and endosperm. × 36.

Cyclanthera explodens (PLATE 68).

160. Apex of young nucellus about the time of the appearance of the archesporium. × 440.

161. Spore-mother-cell and tapetum. × 440.

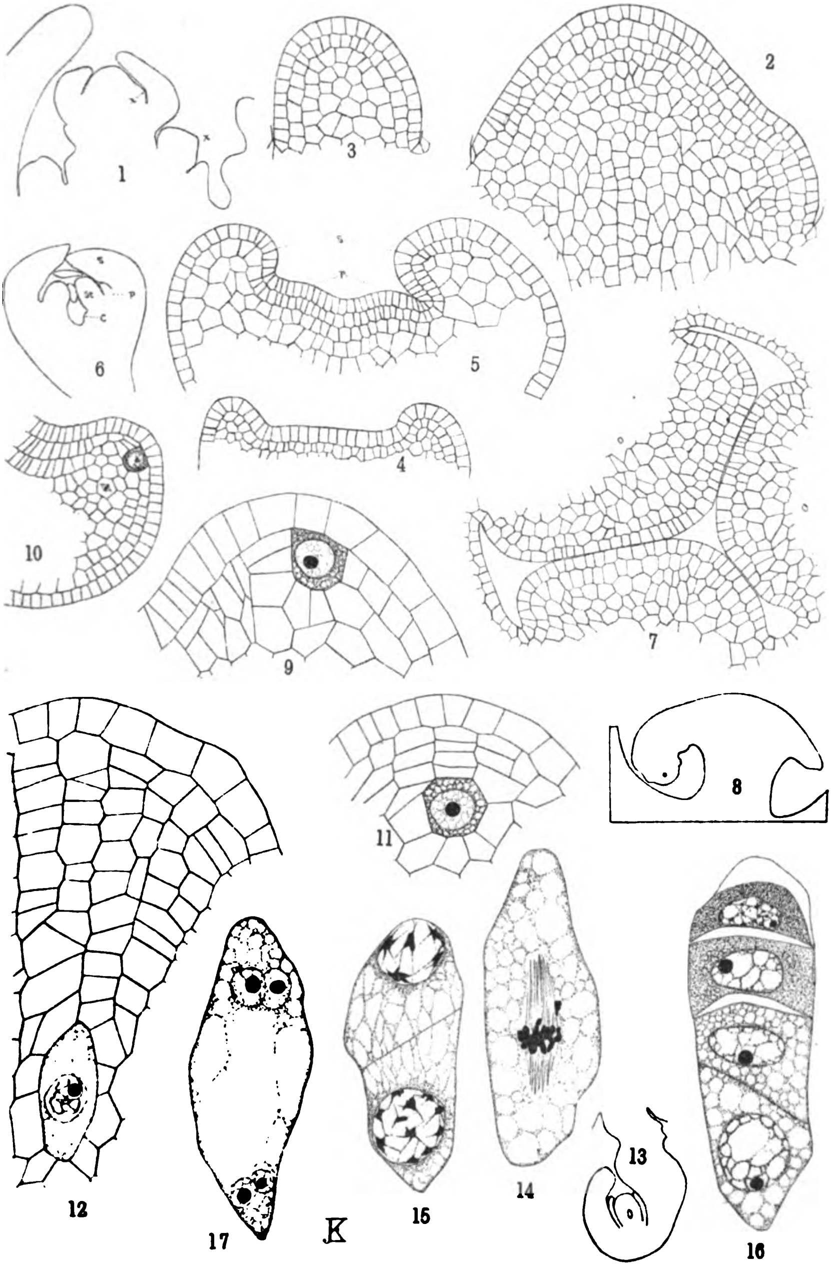
162. Showing the megaspore and its position with reference to the apex of the nucellus. × 440.

163. Embryo-sac of two cells. × 440.

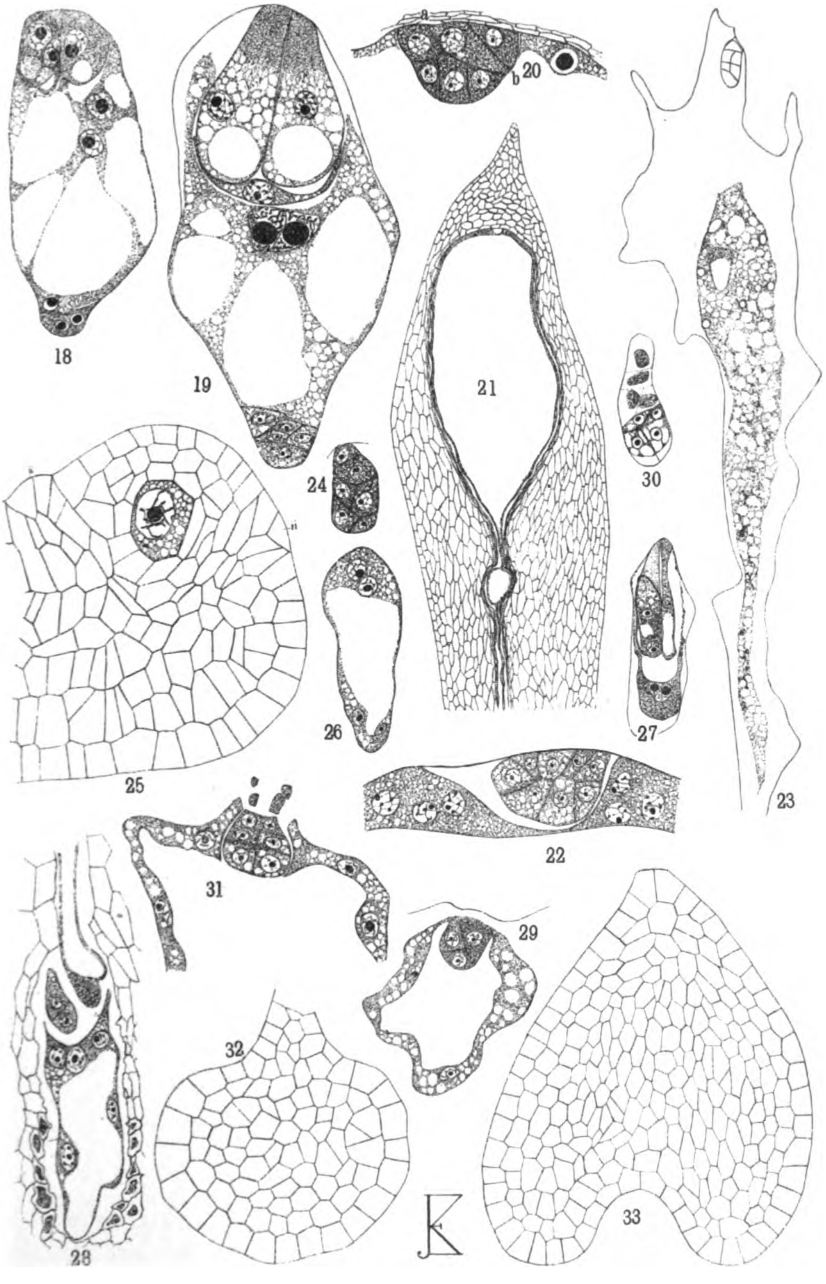
164. Embryo-sac nearly mature. × 440.

165. Young embryo-sac and endosperm. × 440.

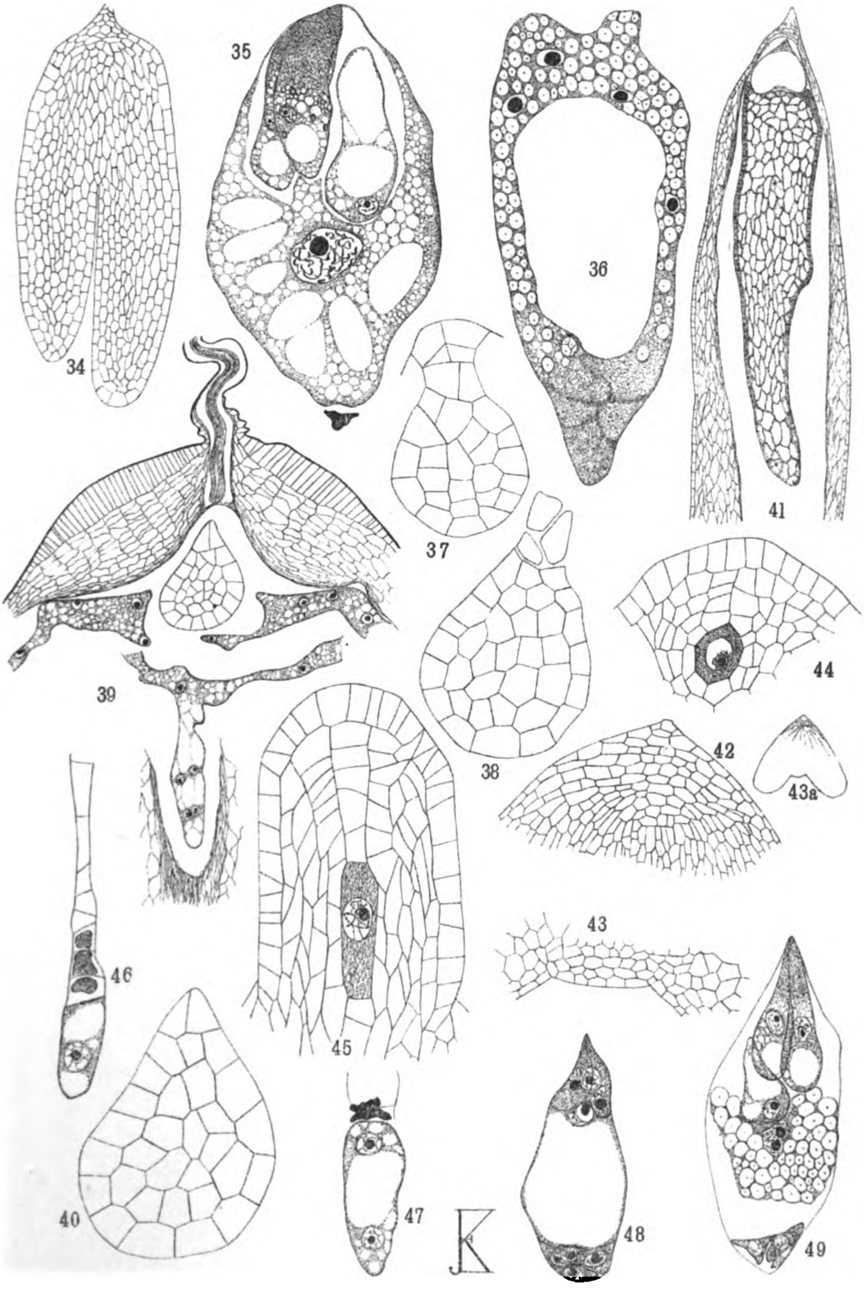
166. Showing form of ovule, the pollen-tube, the endosperm and the portion of the nucellus disorganized. × 40.



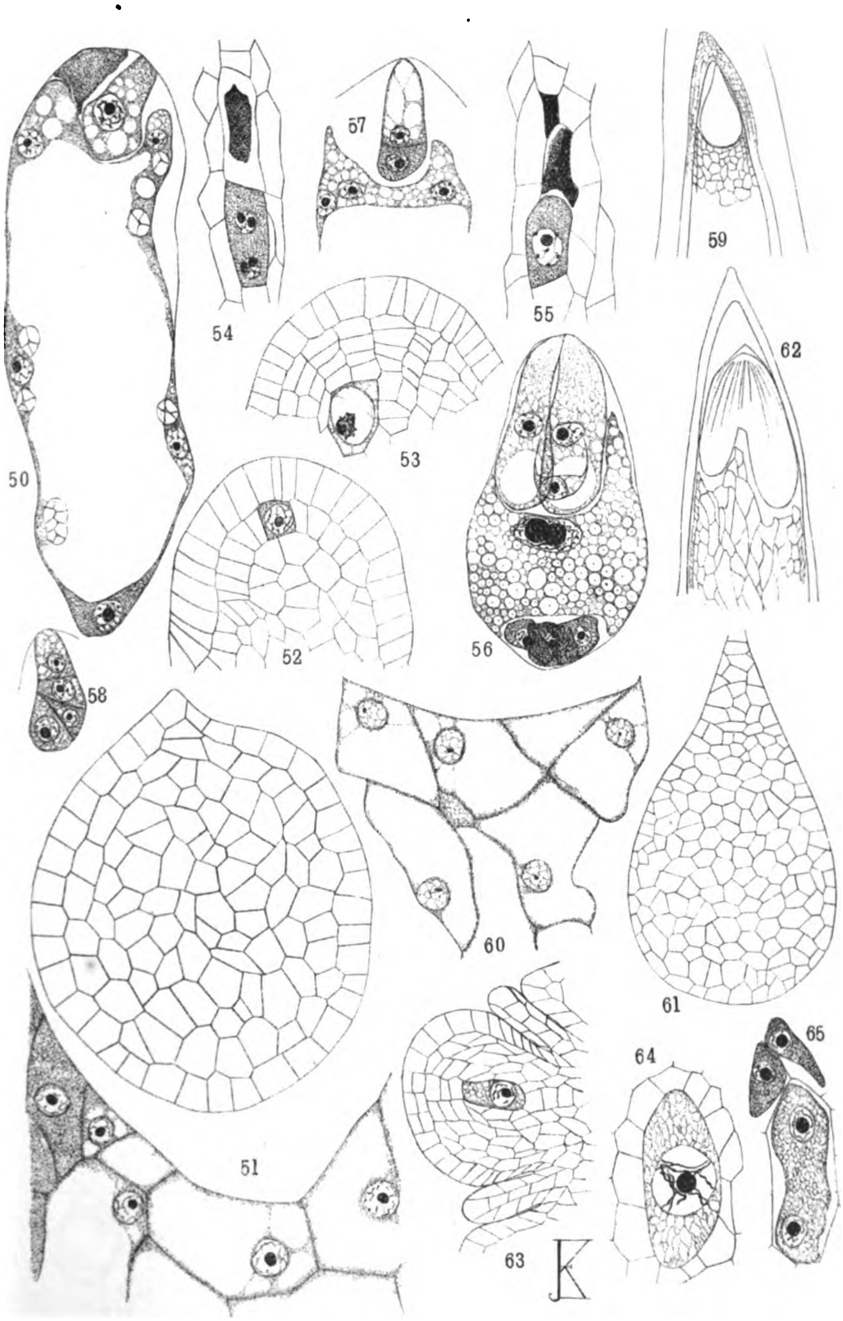
1-17. FEVILLEA CORDIFOLIA.



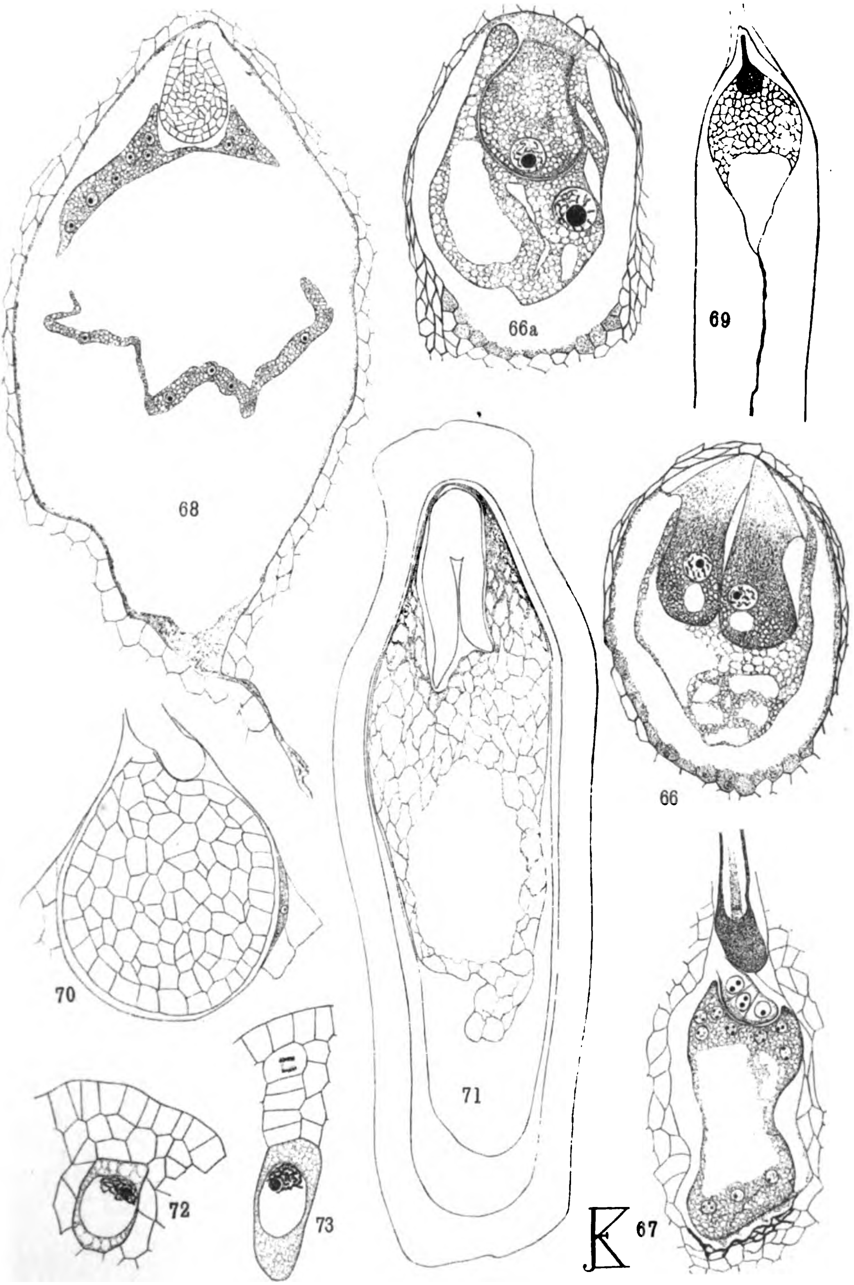
18-24. FEVILLEA CORDIFOLIA. 25-33. MELOTHRIA PENDULA.



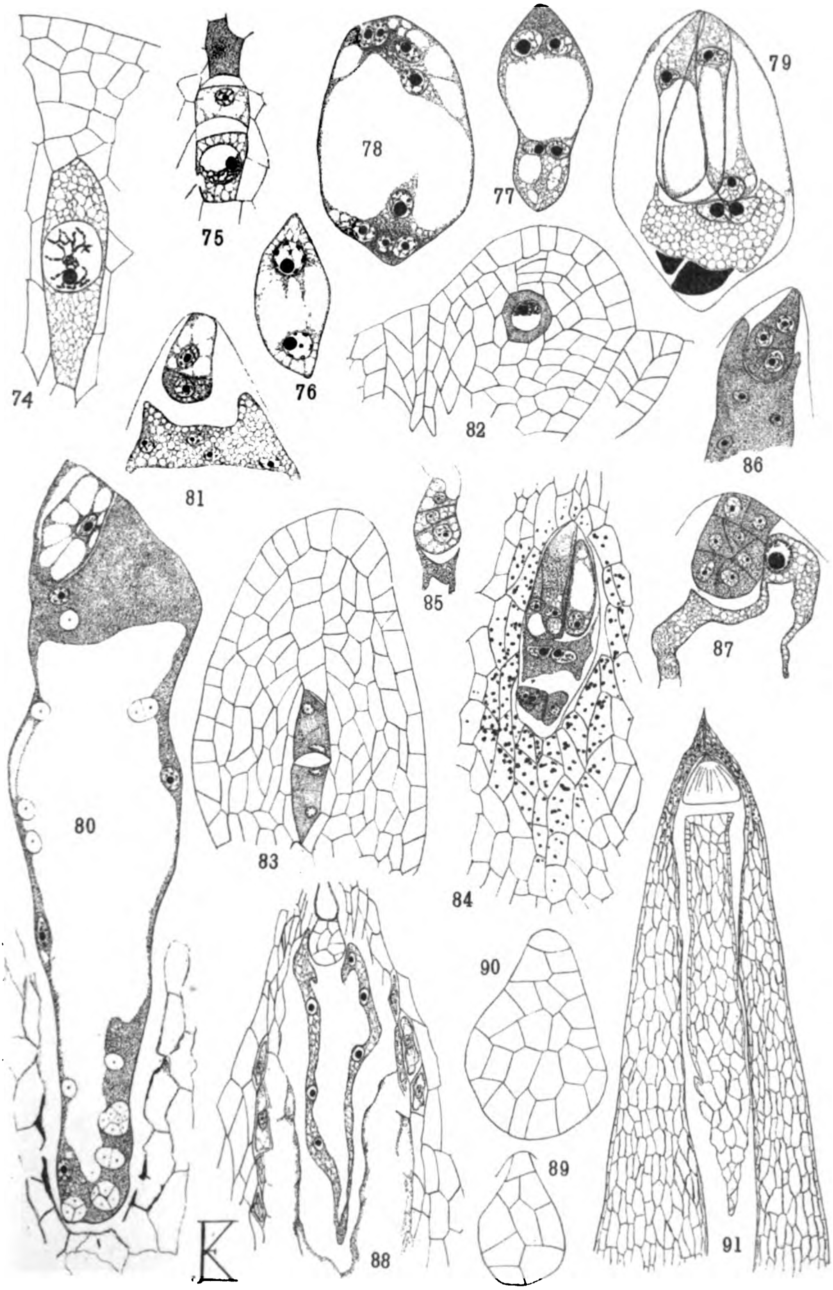
34. MELOTHRIA PENDULA. 35-43a. APODANTHERA UNDULATA.
44-49. BRYONOPSIS LACINIOSA.



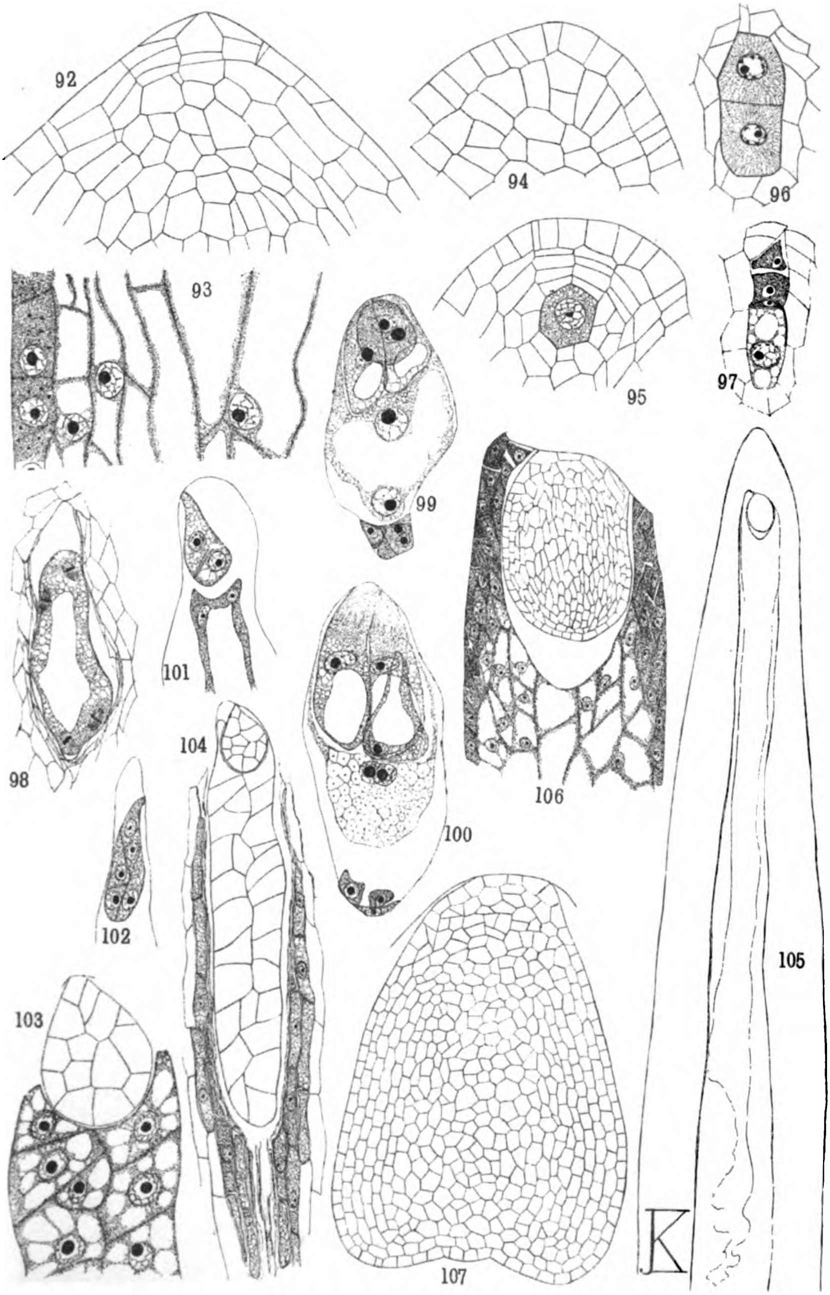
50-51. BRYONOPSIS LACINIOSA. 52-62. TRICHOSANTHES ANGUINA.
63-65. MOMORDICA CHARANTIA.



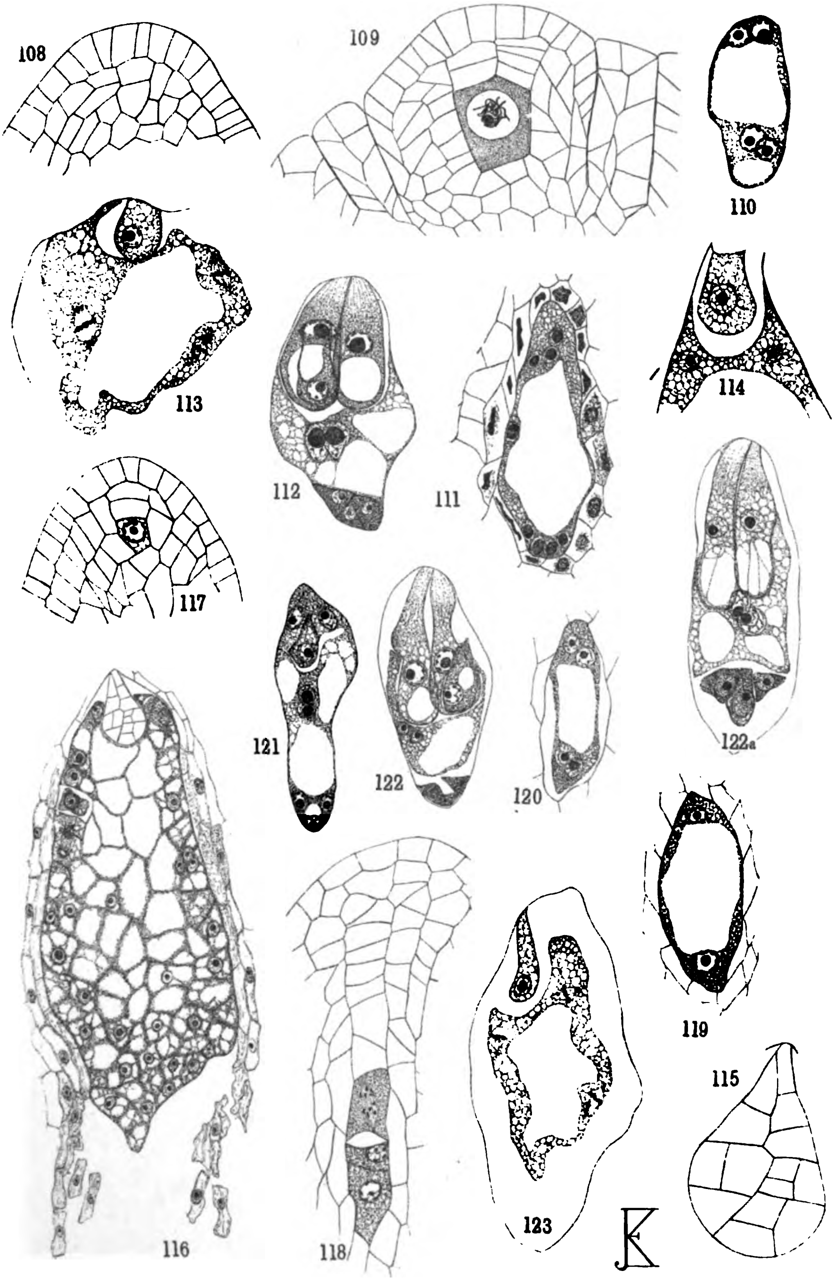
66-71. MOMORDICA CHARANTIA. 72-73. LUFFA ACUTANGULA.



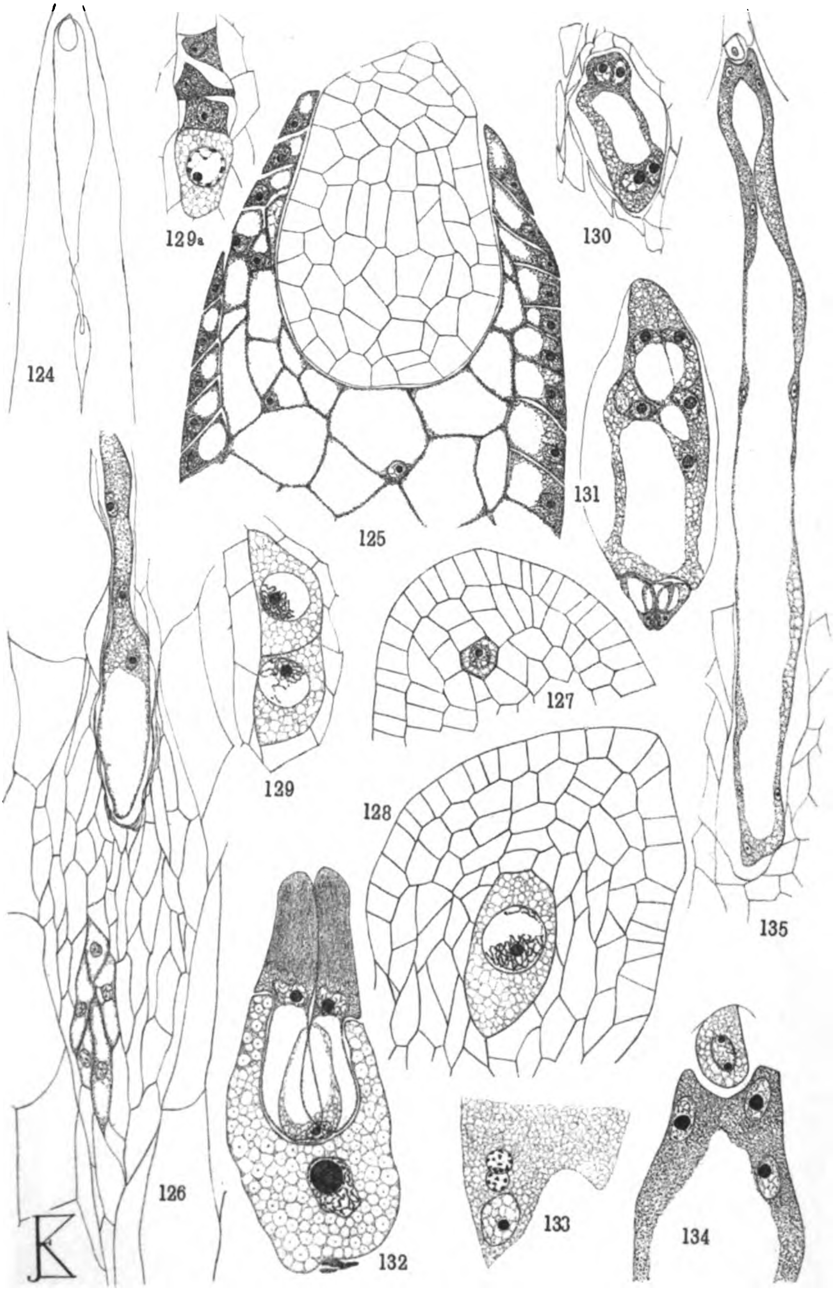
74-81. LUFFA ACUTANGULA. 82-91. CUCUMIS MYRIOCARPUS.



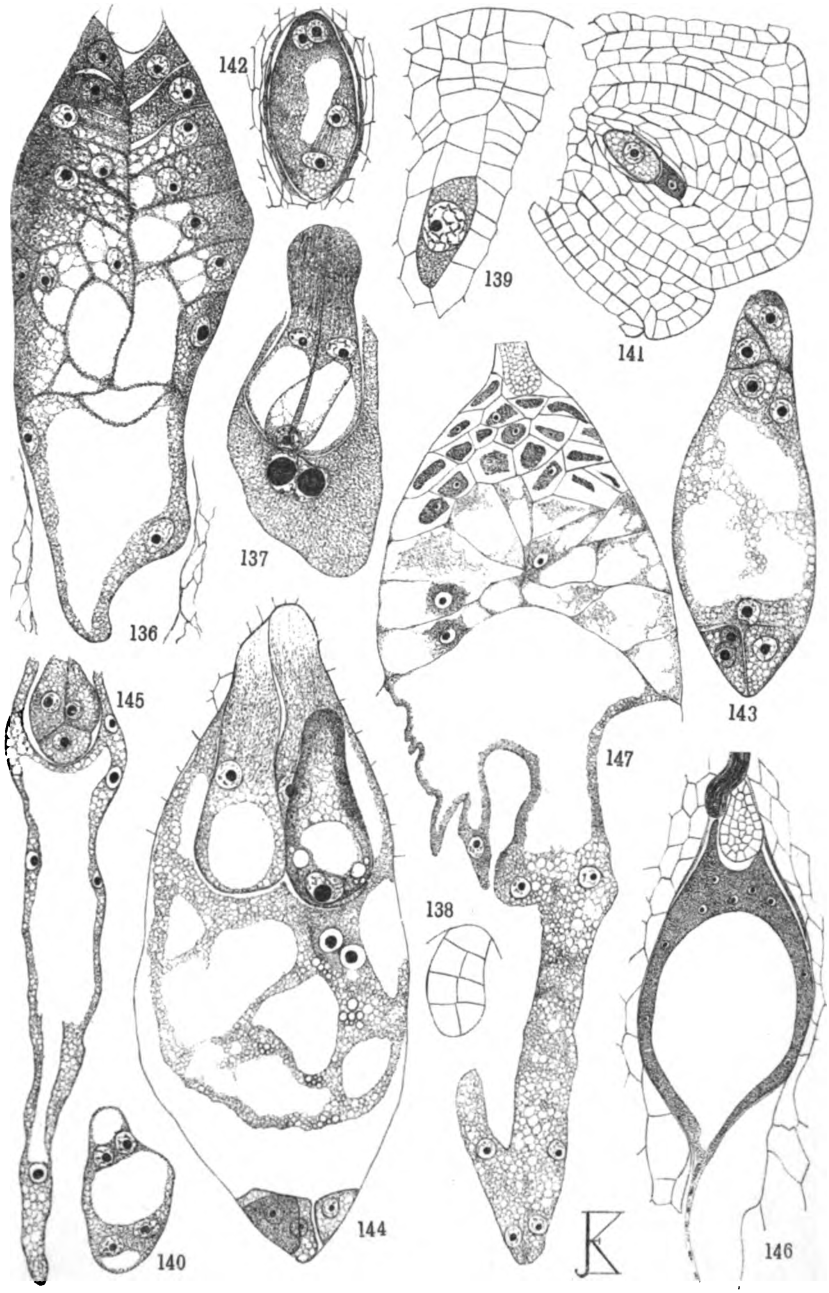
92-93. CUCUMIS MYRIOCARPUS. 94-107. LAGENARIA LAGENARIA.



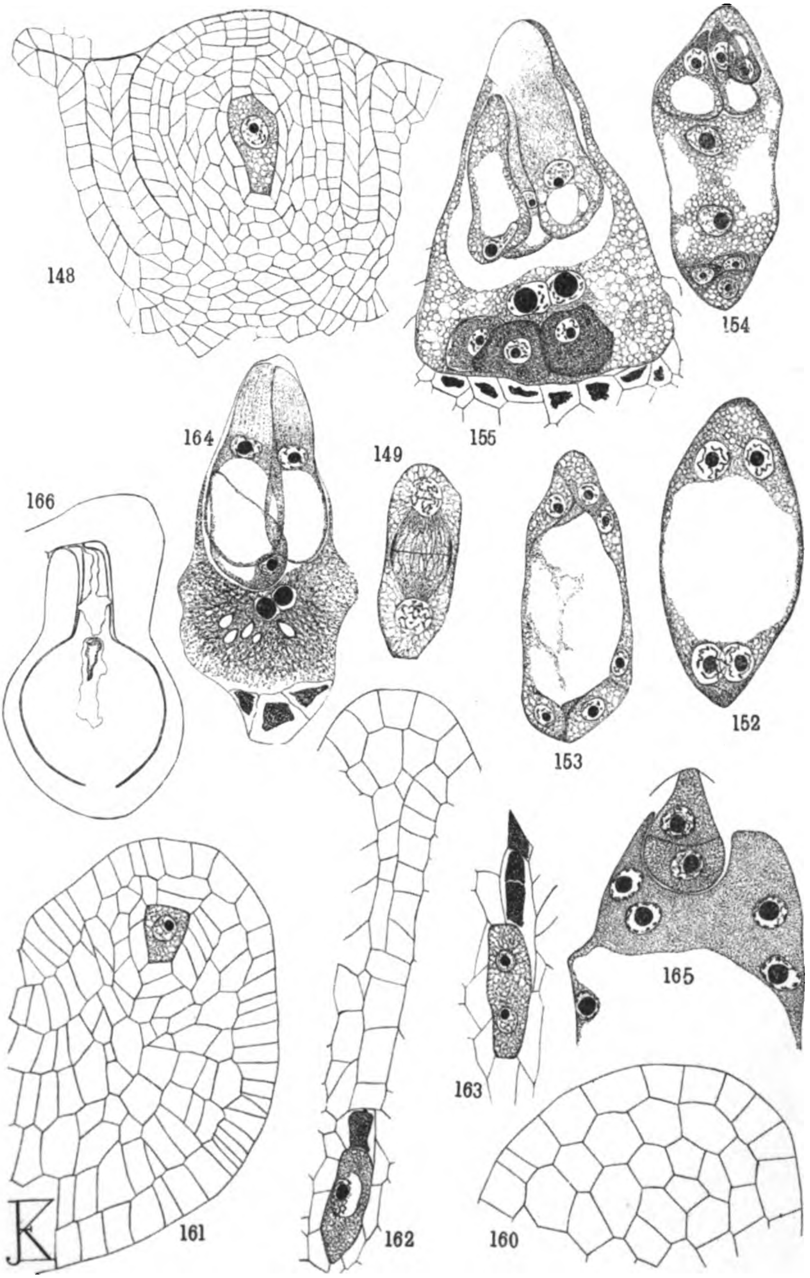
108-116. BENINCASA HISPIDA. 117-123. CITRULLUS CITRULLUS.



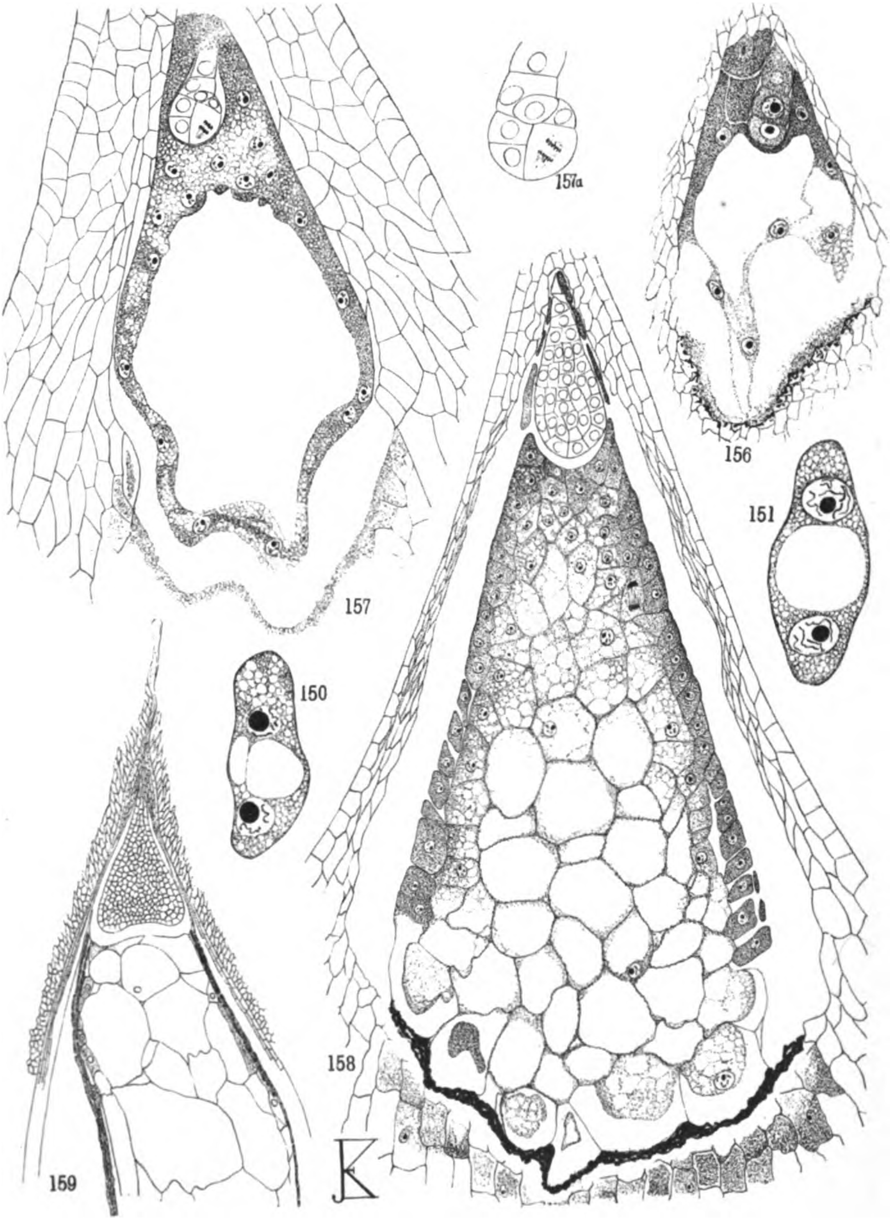
124-126 CITRULLUS CITRULLUS. 127-135. CUCURBITA PEPO.



136-138. CUCURBITA PEPO. 139-140. COCCINIA CORDIFOLIA.
141-147. SICYOS ANGULATA.



148-149; 152-155. MICRAMPELIS LOBATA. 160-166. CYCLANTHERA EXPLODENS.



150-151; 156-159 MICRAMPELIS LOBATA.

CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 213

THE NOMENCLATURE OF CALONYCTION BONA-NOX

By HOMER D. HOUSE

NEW YORK

1904

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 31: 589-592. November, 1904.]

The nomenclature of Calonyction bona-nox

HOMER D. HOUSE

The species described in Dr. Small's recent *Flora of the southeastern United States*, as *Calonyction bona-nox*,* is known under the common name of moonflower. A study of available herbarium material shows that two very distinct species are represented, and in an effort to determine their proper status a formidable array of synonymy is encountered. The condition of affairs was pointed out by Kuntze † in 1891, and briefly the facts are as follows: In the first edition of *Species Plantarum*, Linnaeus describes *Convolvulus aculeatus* ‡ and *Ipomoea alba*.§ Later, Linnaeus combines them under the name of *Ipomoea bona-nox*,‖ and includes there nearly all of the citations given under the two previously named species. *Ipomoea alba* is again taken out under the name of *Convolvulus grandiflorus*,¶ and given the same pre-Linnaean citation as *Ipomoea alba* with an additional citation. These changes may be shown by the following tabulation.

Pre-Linnaean citations.	*Convolvulus aculeatus* L 1753.	*Ipomoea alba* L. 1753.	*Ipomoea bona-nox* L. 1762.	*Convolvulus grandiflorus* L f. 1781.
Hort. Cliff. 496.	×		×	
Pluk. Alm. *t. 276. f. 3.*	×		×	
Sloan. Jam. 55; Hist. 1: *t. 96. f.* 1.	×		×	
Raj. Suppl. 371.	×			
Bauh. Pin. 296.	×	×	×	×
Rheed. Mal. 11: *t. 50.*			×	
Herm. Mus.				×

The genus *Calonyction* Choisy ** is based upon the characters of large salverform corolla, exserted stamens and thickened pedicels. The type is *Calonyction speciosum* Choisy,* which includes at least the Linnaean species *Convolvulus aculeatus* and *C. muricatus.* The revised nomenclatorial status, therefore, of the two species under consideration may be presented as follows:

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* Small, J. K. Flora of the Southeastern United States, 961. 1903.

† Kuntze, O. Rev. Gen. 442. 1891.

‡ Sp. Pl. 155. 1753.

§ Sp. Pl. 161. 1753.

‖ Sp. Pl. Ed. 2, 228. 1762.

¶ Linn. f. Supplement, 136. 1781.

** Choisy. Mem. Soc. Phys. Genev. 6: 440. 1833.—Conv. Or. 59. 1834.—In DC Prodr. 9: 345. 1845.

Calonyction aculeatum (L.) comb. nov.

Convolvulus aculeatus L. Sp. Pl. 155. 1753.

Ipomoea bona-nox L. Sp. Pl. Ed. 2, 228. 1762. In part.—Jacq. Hort. Schoenb. **1**: 16. 1797.

Convolvulus latiflorus Desr. Encyc. **3**: 537. 1790.

Calonyction speciosum Choisy, Mem. Soc. Phys. Genev. **6**: 441. 1833.—In DC. Prodr. **9**: 345. 1845. In part, excl. vars. β and γ, at least.

Calonyction bona-nox Boj. Hort. Maurit. 228. 1837.—Small, Fl. S. E. U. S. 961. 1903.

Ipomoea aculeata Kuntze, Rev. Gen. 442. 1891.—Blume, Bijdr. 715. 1825 (according to Choisy but not according to Kuntze).—G. Don, Gen. Syst. **4**: 270. 1838.

Convolvulus foliis cordatis, caule aculeato L. Hort. Cliff. 496.

Convolvulus americanus, subrotundis foliis, viticulis spinosis Pluk. Alm. 115.

Convolvulus maximus, caule spinulis, etc. Sloane, Jam. 55; Hist. 1: 151.

Smilax aspera Indiae occidentalis Bauh. Pin. 296.

Characterized by a smooth or muricate, high-twining stem with milk-like sap: leaf-blades glabrous, ovate or suborbicular, 5–15 cm. long, entire or variously 3–5-lobed, acuminate, cordate, of a thin, somewhat membranaceous texture: peduncles axillary, one- to several-flowered; pedicels becoming much thickened in fruit: sepals appressed to the corolla, about 1.5 cm. long, all, or at least the outer, with infraterminal tail-like appendages: corolla white, nocturnal, strictly salverform, tube 8–12 cm. long, limb 6–10 cm. broad: capsules ovoid, 2 cm. high; seeds dark brown or nearly black, shining, but very minutely pubescent, sometimes strongly so.

TYPE LOCALITY: Tropical America.

DISTRIBUTION: Florida; western Mexico to Central and South America; West Indies and the tropical regions of the Old World.

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* Choisy, *l. c.*

ILLUSTRATIONS: Pluk. Alm. *pl. 276. f. 3;* Sloane, Hist. **1**: *pl. 96. f. 1;* Jacq. Hort. Schoenb. **1**: *pl. 36;* Cav. Ic. **3**: *pl. 300;* Gaertn. Sem. **2**: *pl. 134. f. 3;* Vell. Fl. Flum. **2**: *pl. 54;* Bot. Repos. **6**: *pl. 403;* Bot. Mag. *pl. 752;* Bot. Reg. *pl. 889*, and *pl. 917*.

Among the many sheets examined the following may be cited:

FLORIDA. Newport, Key Largo, *Pollard, Collins & Morris 170*, 1898. Everglades, west of Miami, *Small & Nash*, 1901. Snapper Creek, south of Cocoanut Grove, *Small & Nash*, 1901. Miami, *Small & Carter 675*, 1903; *A. P. Garber*, June, 1877; *Britton 419*, 1904. Myers, Lee Co., *A. S. Hitchcock 225* and *226*, 1900. Steamboat Key, *Tracy 6789*, 1900. Eustis, Lake Co., *Nash 1333*, 1894. Jupiter Inlet, *A. H. Curtiss 5543*, 1895.

MEXICO. Lower California, *C. A. Purpus 530*, 1901. Maleje, Lower Calif., *Palmer 33*, 1887. Tres Marias Isl., *Nelson 4269*, 1897. Mazatlan, *W. G. Wright 1212*, 1888. Chapala, Jalisco, *Palmer 727*, 1886. Orizaba, *F. Muller 3017*, 1855. Oaxaca, *Holway 3735*, 1899; *Chas. L. Smith 904*, 1894. Yucatan, *Gaumer 330*.

WEST INDIES. Matanzas, Cuba, *Britton & Shafer 264* and *517*, 1903. Pinar del Rio, Cuba, *Palmer & Riley 657*, 1900; *Shafer 529*, 1903. Cienequinta, Santa Clara, Cuba, *Combs 716*, 1896. Santiago, Cuba, *Hamilton 6* and *9*, 1902. Porto Rico, *Mr. & Mrs. A. A. Heller 375*, 1899.

The form with 3–5-lobed and subhastate leaf-blades is described as var. *heterophylla* by Kuntze,* but cannot be regarded as a subspecies.

Calonyction album (L.) comb. nov.

Ipomoea alba L. Sp. Pl. 161. 1753.

Ipomoea bona-nox L. Sp. Pl. Ed. 2, 228. 1762. In part.

Convolvulus grandiflorus L. f. Suppl. 136. 1781.

Ipomoea longiflora R. Br. Prodr. **1**: 484. 1810.

Calonyction grandiflorum Choisy, Mem. Soc. Phys. Genev. **6**: 442. 1833.—Conv. Or. 60. 1834.—In DC. Prodr. **9**: 346. 1845.

Calonyction speciosum var. γ *pubesceus* Choisy, in DC. Prodr. **9**: 345. 1845.

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* Kuntze. Rev. Gen. 442. 1891.

Munda Valli Rheede, Mal. **11**: 103.

Similar to *C. aculeatum*. The stem not muricate, but covered with a thin, whitish, often rough or pubescent bark: peduncles and pedicels very stout: leaf-blades ovate, deeply cordate, entire, acuminate, of a thick and somewhat coriaceous texture, prominently reticulate-veined and slightly pubescent beneath: sepals ovate, thick and coriaceous, rounded or blunt at the apex, apparently never appendaged: corolla larger than in the preceding species, 12–18 cm. long, the limb 8–15 cm. broad.

TYPE LOCALITY: Malabar.

DISTRIBUTION: Florida Keys; Bahamas and St. Vincent. Also St. Domingo and St. Thomas (*fide* Choisy). Common in the tropics of India and the East Indies. Perhaps introduced into America.

ILLUSTRATIONS: Rheede, Mal. **11**: *pl. 50;* Jacq. Hort. Vind. 3: *pl. 69.*

The following specimens have been examined from North America and compared with old world specimens:

FLORIDA. Elliotts Key, *Small & Nash*, Nov. 6 and 7, 1901; *N. L. Britton 378*, 1904.

BAHAMAS. South Cat Cay, *Millspaugh 2416*, 1904. Rum Cay, *Coker 445*, 1903. Salt Cay, New Providence, *John I. & Alice R. Northrop 244*, 1890.

ST. VINCENT. *H. H. & G. W. Smith*, March, 1890.

A perplexing array of synonymy can be attached to each of the above species, but no attempt will be made to assign these numerous names at the present time, lest mistakes in so doing might be misleading as regards the identity of the two species above described.

NATIONAL MUSEUM, WASHINGTON, D. C.

The Publications of the Department of Botany, Columbia University, consist of Memoirs in quarto and Contributions in octavo.

The Memoirs already published are:—

Vol I. **Small.** A Monograph of the North American Species of the Genus *Polygonum.* Pp. 178. 84 plates. 1895. Price, sixdollars.

Vol. II. **Rydberg.** A Monograph of the North American Potentilleae. Pp. 224. 112 plates. 1898. Price, six dollars.

The Contributions have now reached the ninth volume.

Vol. I. Nos. 1–25 (1886–1892). Out of print, except Nos. 6, 7, 11, 13, 17, 20, 21, 22, 24. These can be supplied at twenty five cents each, except No. 6, which is one dollar.

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* Nos 157 and 158, with the set of nine papers by Mr. Bicknell on *Sisyrinchium*, can be had for one dollar and fifty cents.

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OCT

CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 214

THE EARLY WRITERS ON FERNS AND THEIR COLLECTIONS—I–IV

By L. M. UNDERWOOD

NEW YORK

1903–1905

[From Torreya, 3: 145–150. 30 O 1903; 4: 49–52. 28 Ap 1904; 4: 145–150. 29 O 1904;
5: 37–41. 22 Mr 1905]

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THE EARLY WRITERS ON FERNS AND THEIR COLLECTIONS.—I. LINNAEUS, 1707–1778

BY L. M. UNDERWOOD

A little two-volume leather-bound book bearing on its title-page the words, *Species Plantarum*, 1753, has now become quite rare from the demands made since the Berlin, Rochester, and Genoa decisions of 1892 made it the starting point of botanical nomenclature. Many people still hold the erroneous opinion that Linnaeus was the originator of binominal nomenclature. The first book to figure American ferns was published in 1635,* nearly a hundred years before Linnaeus published a line, and gave illustrations and descriptions of two of our American species, calling them *Filix baccifera* and *Adiantum Americanum*, names which by right they should bear instead of those adopted a hundred and eighteen years later by Linnaeus. The same work included many other binomial names some of which, like *Asaron Canadense*, are the names the plants still bear. In *Species Plantarum* Linnaeus simply brought together in a compact and usable form a condensation of the enormous mass of botanical publication that preceded him and reduced the whole to a system which though artificial is readily accessible, which fact has invested his volumes with an importance perhaps greater than that of any other single botanical work.

The ferns and fern allies of Linnaeus were grouped under two of the major divisions of his *Class XXIV. Cryptogamia*, FILICES and MUSCI ; the genera recognized, with the number and distribution of species may be seen from the following table :

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* CORNUT. Canadensium plantarum * * * Historia. Paris, 1635.

Genera	Total Species	Europe	Asia	Africa	Temperate America	Tropical America	Common to U. S. and Europe
Filices.							
EQUISETUM.	6	6	—	—	—	—	—
ONOCLEA.	1	—	—	—	1	—	—
OPHIOGLOSSUM.	6	2	2	—	—	2	—
OSMUNDA.	17	5	1	—	4	8	—
ACROSTICHUM.	25	5	6	3	3	10	—
PTERIS.	19	1	3	—	1	15	—
BLECHNUM.	2	—	1	—	—	1	—
HEMIONITIS.	2	—	—	—	—	2	—
LONCHITIS.	3	—	—	—	—	3	—
ASPLENIUM.	20	9	2	—	1	10	—
POLYPODIUM.	58	15	9	—	5	29	2
ADIANTUM.	15	1	3	1	1	9	—
TRICHOMANES.	11	2	3	2	—	6	—
MARSILEA.	2	2	—	—	—	—	—
PILULARIA.	1	1	—	—	—	—	—
ISOETES.	1	1	—	—	—	—	—
Musci.							
LYCOPODIUM.	24	9	7	—	6	4	1
Total.	213	59	37	6	22	99	3

While the above will show that the genera outlined by Linnaeus are commonly recognized genera of to-day, the sense in which he conceived them was far different from our present conception except in the case of the genera *Equisetum*, *Onoclea*, *Blechnum*, and *Adiantum*, which were composed wholly of species still within those genera as now accepted. *Ophioglossum*, based on the familiar adder-tongue fern of Europe, which had been known as *Ophioglossum vulgatum* at least since the publication of Bauhin's *Pinax* (1671), also included the tropical *Cheiroglossa* and two Asiatic species of climbing ferns (*Lygodium*). *Osmunda* was still more of a mixture and included nearly everything known to Linnaeus which had a semblance of a panicle, although the royal flowering fern common in Europe was clearly the historic type of the genus. The genus *Osmunda* of Linnaeus contained what are now distributed amoung four families representing two distinct orders of plants, viz.: *Helminthostachys* and two species of *Botrychium* (OPHIOGLOSSACEAE); four species of *Ornithopteris* and *Anemia* (SCHIZAEACEAE); four species of *Osmunda* proper (OSMUNDACEAE), one species each in *Matteuccia*, *Struthiopteris*, *Olfersia*, and *Cryptogramma* (POLYPODIACEAE) besides one tropical American species not yet identified.

Acrostichum as outlined by Linnaeus contained ferns having the sporangia scattered in a layer over the under surface of the leaf, and in separating the members of this group, he did not distinguish those which have distinct sori when young which later become confluent. Without these his genus formed a sufficiently unnatural group, containing as it did species of *Schizaea*, *Danaea*, *Stenochlaena*, *Ceratopteris*, *Hymenodium*, and *Todea* in addition to *Acrostichum aureum*, the type of the genus, and to these were added *Polypodium polypodioides*, *Asplenium platyneuron*, *Asplenium septentrionale*, *Lorinseria areolata*, *Woodsia Ilvensis* and *Dryopteris Thelypteris* by way of variety, together with species of *Notholaena*, *Trismeria*, and *Ceropteris*. Should anyone suppose that the fern system of the miscalled "Father of Botany" was anything but crude even for the time at which it was proposed, the contemplation of this array of misfits should serve as convincing evidence to the contrary.

The genus *Pteris* in the *Species Plantarum* is a little better although it contained members of the genera *Vittaria*, *Notholaena*, *Gymnopteris*, *Dryopteris*, *Pteridium*, *Dicranopteris*, and *Pellaea* as now recognized, in addition to species which still help to make up the genus *Pteris* with a single continuous marginal indusium and free veins. *Asplenium* was a somewhat more natural aggregate commencing with the single-leaved species of *Camptosorus*, *Phyllitis*, and *Thamnopteris*, and passing on to *Ceterach* and the more divided members of the genus *Asplenium*, now distributed among several genera but, with perhaps a single exception, all members of the tribe *Asplenieae* as now recognized. A serious relapse occurred again in *Polypodium* which included all the species with rounded sori whether indusiate or not; besides representatives of the various genera still included under *Polypodium* in certain quarters, *Polypodium* of *Species Plantarum* contained species of *Tectaria*, *Polystichum*, and *Phegopteris* together with *Asplenium fontanum*, *A. filix-foemina*, several species of *Dryopteris*, including *D. filix-mas*, *D. cristata*, *D. Noveboracensis*, and *D. marginalis*, *Filix bulbifera* and *F. fragilis*, *Cibotium Barometz*, *Cyathea arborea*, *Hemitelia horrida*, *Alsophila aspera*, and others equally diverse in character.

The genus *Trichomanes* whose name Linnaeus transferred from our little tufted spleenwort to the tropical filmies, included some species of *Hymenophyllum* and at least one *Davallia*. *Marsilea* included *Salvinia natans* and *Marsilea quadrifolia*, now recognized as types of two different families of the *Salviniales*, and *Pilularia* and *Isoetes* were monotypic, each including the more common species of northern Europe.

It was perhaps natural for *Lycopodium* with narrow leaves to have been associated with the leafy mosses under MUSCI, but it was strange that the foliose hepatics with the single exception of *Porella* should have been placed apart under ALGAE. The genus *Lycopodium* of *Species Plantarum* contains twelve species still included under the genus, together with *Psilotum nudum* and eleven species of *Selaginella*.

It is highly improbable that Linnaeus knew many of the pteridophytes which he arranged in this work, save the few with which he was familiar in northern Europe. By far the greater number of his species were compiled from books and his only knowledge came from the more or less accurate illustrations with which he was familiar.

The apparently undue proportion of tropical American species was due to the early works of Plumier and Sloane, which had been copied by Petiver and probably by Plukenet. Sir Hans Sloane collected extensively in Jamaica toward the close of the seventeenth century, and Charles Plumier collected in Santo Domingo and Martinique at about the same time. The elaborate folio works of these two early writers form the foundation of our knowledge of West Indian botany, and while they were digested by Linnaeus only in part, they furnished him the basis for his species of West India ferns. Later writers have traced many additional species to the same early sources that Linnaeus only skimmed, but did not fathom or comprehend.

Linnaeus' herbarium was probably made, at least in great part, after the publication of the first edition of *Species Plantarum*, and on that account is of comparatively little value for the determination of his types. It is preserved at London in the rooms of the Linnaean Society. After the death of Linnaeus' son, the collection reverted to the widow of Linnaeus by whom it was sold to Sir J. E. Smith, for many years president of the Linnaean Society. After Smith's death it was purchased with other collections for the Linnaean Society at a sum that almost paralyzed the society for a quarter of a century. The plants are in an excellent state of preservation and are on sheets about the size of small foolscap paper. The sheets of each genus are protected by heavy wrappers which entirely enclose the packets; the genera are systematically arranged in the original cases in which Linnaeus left them, protected by clumsy Swedish locks, and these cases are again placed in others still larger with glass fronts which stand in the assembly room of the Society.

During the past summer we examined the plants of the genera *Osmunda*, *Acrostichum*, and *Polypodium* and found the material scrappy, often consisting of mere tips of leaves, rarely with any rootstocks, and often wholly sterile. Only a small part of his species are represented by specimens at all, and those that are often do not correspond with the species described in his works. Two instances will show the nature of the discrepancies:

Under *Osmunda Lunaria* (= *Botrychium Lunaria*) the only plant preserved is one of *Botrychium matricariae*.

Under *Osmunda bipinnata*, a West Indian species described from Plumier's plate which represents a very close ally of *Osmunda cinnamomea*, the only plant is one of *Ornithopteris cicutaria* (Kze.), a plant bearing no resemblance to Plumier's plate! Moore, who made this same discovery, promptly transferred *Anemia cicutaria* Kze. to *Anemia bipinnata* (L.) Moore and the name was as promptly adopted in *Species Filicum* at Kew for this species, a proceeding that cannot hold for manifest reasons. The types of Linnaeus must very largely depend on the plates and descriptions of the early writers from which he quoted. Of these there are twenty-seven works containing descriptions of extra-European ferns from which Linnaeus made citations, to say nothing of thirty-five or more European herbals which were also cited. Considering the number of ferns named by Linnaeus, his original contribution to the knowledge of them was very limited, although he did describe a few species from plants collected by

Kalm in America and by Osbeck in China, and he must ever plead guilty to the charge of needlessly changing names already given by his predecessors.

[Reprinted from TORREYA, Vol. 4, No. 4, April, 1904.]

THE EARLY WRITERS ON FERNS AND THEIR COLLECTIONS — II. J. E. SMITH, 1759–1828; SWARTZ, 1760–1818; WILLDENOW, 1765–1812

BY L. M. UNDERWOOD

Aside from minor changes in the generic arrangement of Linnaeus * and occasional additions to the number of species by various writers, notably Thunberg, Forskål, Forster, Lamarck, and Cavanilles, the principal generic changes as well as the more extensive additions to fern species up to the end of the first decade of the last century were made by Smith, Swartz, and Willdenow. Sir James Edward Smith is not to be confused with the less eminent, but so far as fern lore is concerned, more distinguished John Smith who flourished a half century or more later. Smith published in 1793 an important paper † which was one of the first attempts at a natural classification of ferns. He established the genera *Woodwardia*, *Vittaria*, *Davallia*, *Cyathea*, *Hymenophyllum*, *Gleichenia*, and *Danaea*. While some of these, like *Cyathea*,‡ for example, were highly unnatural groups, the generic arrangement was far in advance of anything that preceded it.

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* Theodor Holm (TORREYA, 3: 187–188) has taken exceptions to my statement regarding the types of Linnaeus. It is well known that Linnaeus' one-line descriptions of ferns are worthless, and in many cases he gives only citations. As I have shown, among the ferns at least, his types are equally so, and Mr. Holm says even worse things about them. There is therefore nothing left on which to depend for identifying his types but his citations and, on these, rational interpreters of Linnaeus have hitherto depended for identifications. If now, as Mr. Holm avers, these are not to be regarded as typical of his species but merely as giving "some idea of their general habit or aspect," Linnaeus becomes from a systematic standpoint even more useless than we have given him credit for being.

We examined the specimen preserved under *Osmunda Lunaria* in herb. Linnaeus last summer and it was labeled as before stated.

† Tentamen Botanicum de Filicum generibus dorsiferarum. Mem. Acad. Sci. Turin, 5: 401–422. *pl. 9.* 1793 (also sep. pp. 22). Smith also published various articles on ferns in Rees' Cyclopaedia, which was published between 1802 and 1819.

‡ *Cyathea* besides containing three genera of tree ferns as now understood included also two of our delicate bladder ferns (*Filix*)!

Smith was president of the Linnean Society (London) for many years and after his death his collection was purchased by the society, at whose rooms it is now easily accessible for examination. The plants are well preserved, but, as in many of the early collections, many ferns are represented by tips of leaves only and some of these have served as types of new species.

Olof Swartz issued the first formal enumeration of all known ferns in his *Synopsis Filicum* (1806) and presented the next general conspectus of fern genera. In this and previous works he described a large number of species and established the genera *Marattia*, *Grammitis*, *Aspidium*, *Diplazium*, *Lygodium*, *Botrychium*, *Cheilanthes*, *Anemia*, *Mohria*, and *Psilotum*. His *Synopsis* recognized thirty-eight genera and his work is usually regarded as the first real datum-line for the systematic study of ferns. To show how clearly he outlined the system so long familiar to fern students in the later *Synopsis Filicum* of Hooker and Baker (1868, 1874) we give an outline of his classification:

I. GYRATAE

Soris nudis

ACROSTICHUM (46*), MENISCIUM (3), HEMIONITIS (8), GRAMMITIS (13), TAENITIS (1), POLYPODIUM (102).

Soris indusiatis

ASPIDIUM (93), ASPLENIUM (75), CAENOPTERIS (9), SCOLOPENDRIUM (2), DIPLAZIUM (9), LONCHITIS (4), PTERIS (79), VITTARIA (6), ONOCLEA (12), BLECHNUM (14), WOODWARDIA (8), LINDSAEA (14), ADIANTUM (32), CHEILANTHES (16), DAVALLIA (29), DICKSONIA (16), CYATHEA (10), TRICHOMANES (21), HYMENOPHYLLUM (28).

II. SPURIE GYRATAE

Capsulis rimatis

SCHIZAEA (6), LYGODIUM (11), ANEMIA (17), MOHRIA (1), OSMUNDA (6), TODEA (1), MERTENSIA (7), GLEICHENIA (3), ANGIOPTERIS (1).

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* The numbers in parentheses indicate the number of species of each genus described in the *Synopsis*.

III. AGYRATAE

Capsulis multilocularibus

MARATTIA (4), DANAEA (2).

Capsulis bivalvibus

OPHIOGLOSSUM (9), BOTRYCHIUM (7).

Besides the above genera Swartz also treated under the Lycopodineae the genera LYCOPODIUM (65), TMESIPTERIS (1), and PSILOTUM (2).

Swartz' work is of special importance to us at this time since many of his species were based on collections he made in the West Indies when he visited Jamaica and Haiti in the years 1784–1786. His collection, which we have not yet seen, is preserved at the Academy of Sciences at Stockholm and is said to be in a most excellent state of preservation. Various writers on West Indian ferns, notably Jenman, have referred to various types of Swartz as being found in the British Museum. It is true that some of the earlier botanists occasionally distributed their type material during their lifetime, and it is also true that some specimens of ferns came to the British Museum from Swartz, but there seems to be no warrant or at least no certainty that any of his types ever came there : in fact all the probabilities are against it, and his types must be sought in his native country. Swartz also published shorter papers on ferns, the last being published in 1817, only a year before his death.

The next enumeration of ferns was made by Willdenow in 1810 * in the fifth volume of his edition of *Species Plantarum*, although his work on ferns had commenced in 1802 with his publication of the genera *Todea* and *Hydroglossum* (*Lygodium*) followed in 1804 by *Mertensia*, and in 1809 by *Struthiopteris* and *Lomaria*. His enumeration included 43 genera of ferns and 1008 species, enriched by the collections of Humboldt and Bonpland in meridional America, as well as by those of Bory and others mostly described here as new. Willdenow's collection is

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*An enumeration of the known ferns was commenced by Lamarck in the *Encyclopédie Méthodique* in 1783 and was completed by Poiret in 1808. This however contained only 444 species in contrast with the 716 described by Swartz in 1806, and 1008 described by Willdenow in 1810.

maintained by itself in the Kgl. Bot. Museum at Berlin. Each specimen is numbered serially and all is thoroughly indexed so that the collection is more readily accessible that any other of the historic collections. The sheets enclosed in covers tied with tape after the usual continental method, are arranged in volumes of convenient size and stand side by side in a special case in the room used until recently by the late Professor Schumann for a study. The sheets are a trifle larger than foolscap paper and the plants are mostly in an excellent state of preservation. There is sometimes a little doubt about his "types" being the originals on which he based his species, as he is said at times to have given away his originals in those species of which he afterwards secured better material. Our own Muhlenberg was a correspondent of Willdenow so that his collection includes many species from the United States.

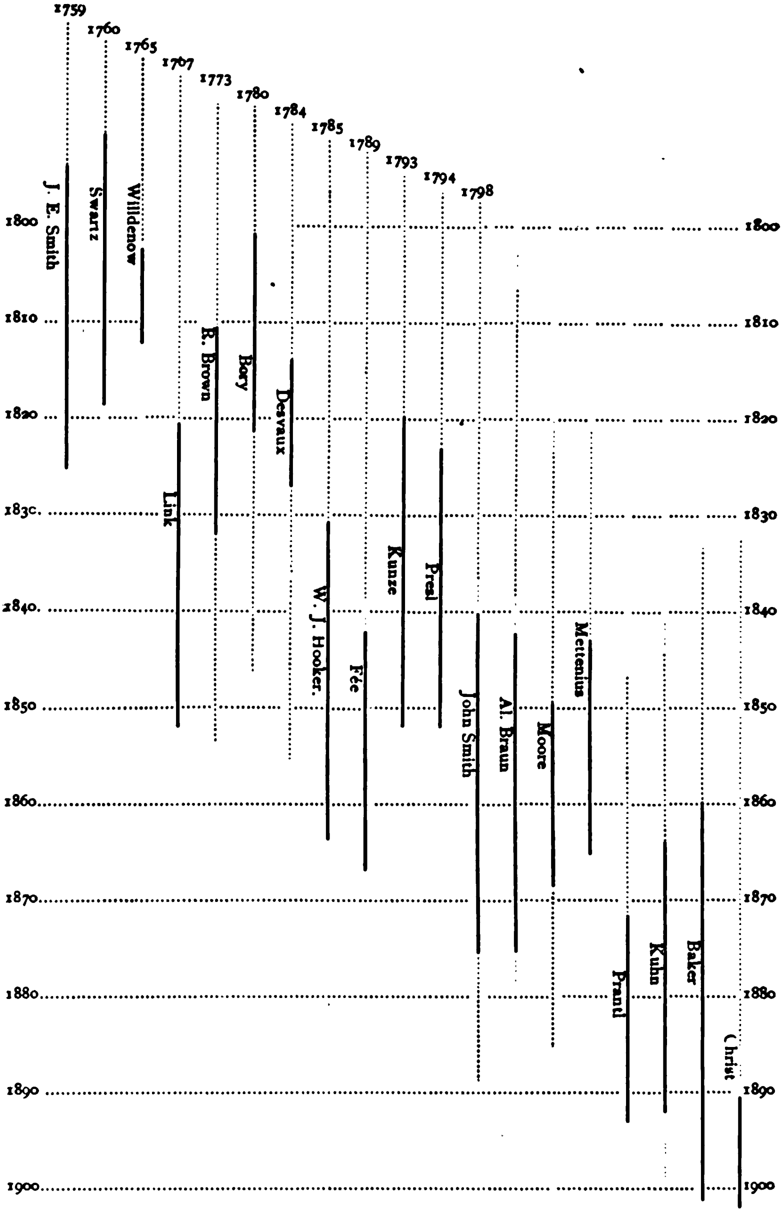
[Reprinted from TORREYA, Vol. 4, No. 10, October, 1904.]

THE EARLY WRITERS ON FERNS AND THEIR COLLECTIONS — III. W. J. HOOKER, 1785–1865

BY L. M. UNDERWOOD

Following the period of J. E. Smith, Swartz, and Willdenow, and partly contemporaneous with it, were two or three men of minor rank in systematic fern study and yet men who did real and lasting work, both in extending the genera of ferns and in describing unknown species. Among these was the distinguished keeper of the botanical department of the British Museum, Robert Brown (1773–1858) whose keen understanding of generic relations among ferns will ever cause us to lament that his publications on the fern system were so limited and incomplete. Bory de St. Vincent (1780–1846) also published a number of fern genera as did also Link, of Berlin (1767–1851). But in the extent of published work, all of these were surpassed by Desvaux (1784–1856) professor of botany at Angers, whose synopsis (1827), the forerunner of modern generic limitations, is one of the too-often neglected but valuable works of the fern systematist of to-day. Desvaux's diagnoses are unfortunately too brief, and his types are often difficult to trace in the Museum of the Jardin des Plantes, but his views were usually rational and as the time goes on his species will be found to compare favorably with those established by others of this period.

In order better to orient the reader with regard to the various periods of systematic fern study we append the following chronological table:



(In the above table the entire line shows the life period, the solid line the period of publication on ferns.)

It is to England, however, that we must look for the greatest advance in the systematic study of ferns during the second quarter of the past century. W. J. Hooker, afterwards Sir William, the first director of Kew Gardens after Queen Victoria had opened them to the public, and father of the present Sir Joseph, who followed his father in that important post in 1865, was born in 1785 and thus was a correspondent in touch with all the earlier writers on ferns of the first years of the century.

In his earlier years of study, Hooker was associated with R. K. Greville, the distinguished cryptogamic botanist of Scotland, and with him published the elaborate folio in two volumes, *Icones Filicum* (1831), besides one or two preliminary papers on ferns and fern allies.* Greville's influence was most salutary in giving to their combined studies what would now be considered a more rational view of the limitation and distribution of species, and thus contrasts most strongly with the narrowly conservative ideas that dominated all the later writings of Sir William and his successors in fern study at Kew. A comparison of a few genera will strongly emphasize this statement.

Genera	Species recognized by Hooker & Greville in 1833	Species included in the first edition of *Synopsis Filicum*, 1868	Species of the *Synopsis* published subsequently to 1833
OPHIOGLOSSUM.	18	10	2
BOTRYCHIUM.	14	6	—
MARATTIA.	10	7	3
DANÆA.	5	11	6
ANGIOPTERIS.	2	1	—
OSMUNDA.	12	6	—
TODEA.	3	4	2

The appointment of Hooker to Kew made possible several opportunities which served to advance our knowledge of ferns and to lay the foundations at that herbarium of its present magnificent collection of ferns:

1. The increased exploration of distant lands made possible by the relation Kew has increasingly maintained towards commercial importation of ornamental plants and more especially by

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* Greville & Hooker. Enumeratio Filicum (I. Lycopodineae). Bot. Miscellany, 2: 360–403. 1831; (II. Ophioglosseae, Marattiaceae, Osmundaceae). Bot. Miscellany, 3: 216–232. 1833. This work was unfortunately discontinued.

the intimate relations early established with the extensive system of colonial gardens and plantations which have ended in these adjuncts being almost wholly manned by men who were trained at Kew.

2. The increased facilities for the publication of extensive series of excellent illustrations of ferns. In this Hooker was greatly aided by the painter, Francis Bauer, to whom we are indebted for the admirable illustrations in *Genera Filicum*, and later by Mr. W. Fitch, for many years the artist of Kew Gardens.

3. By the selection of John Smith in 1841 as the curator of Kew Gardens, whose interest in fern cultivation resulted not only in bringing together the splendid collection of living ferns now in cultivation at that garden, but early laid the foundation of an elaborate generic system of ferns far more philosophical and rational than that followed by Hooker and his successors.

Whatever may be said in criticism of the conservative treatment of fern species or fern genera at Kew, no words can sufficiently convey the appreciation of fern students of every subsequent age for the elaborate and accurate illustrations, the magnificent fern herbarium, and the splendid collection of living ferns which have ever been available for study with a characteristic and open-hearted generosity that could not be exceeded.

Hooker's illustrated publications on ferns were as follows:

1. *Icones Filicum* (conjointly with Greville) 2 vols. 1831. 240 plates (hand-colored in some copies, not in others).
2. *Genera Filicum* (conjointly with Bauer). 1842. 120 colored plates.
3. *Species Filicum*. 1844–1864. 5 volumes of text and 304 plates (uncolored).
4. Garden Ferns. 1852. 64 colored plates.
5. A Century of Ferns. 1854. 100 colored plates. (This was a reissue of volume ten of *Icones Plantarum*, in which the plates were differently numbered and were uncolored).
6. *Filices Exoticae*. 1859. 100 colored plates.
7. A Second Century of Ferns. 1861. 100 colored plates.
8. British Ferns. 1861. 66 colored plates.

Besides the above there were numerous plates of ferns scattered through various volumes of *Icones Plantarum*,* which brings the above total of 1074 plates up to over 1200. As the plates of *Genera Filicum* and *Species Filicum* often contain two or more species, the total number of ferns illustrated from Kew reaches nearly sixteen hundred species.

The Kew herbarium of ferns is by far the largest collection in the world and it is no disparagement to the other great collections to say that no extensive critical systematic work, whether dealing with the ferns of any genus or of any country, can be reasonably complete without consultation of this famous collection. Some of our distinguished German friends are respectfully urged to take the full import of this statement to heart. There is no excuse for continental botanists longer to neglect this obvious duty.

The same criticism here made on continental botanists of the present generation could have applied with equal force to Hooker himself. Notwithstanding his wide correspondence with botanists of his time, there was obvious failure to examine the types of his predecessors in fern study, and justice forces us to add an equal failure to recognize as valid too much of the work of many of his contemporaries. Cases are not wanting, even, where errors could have been easily avoided by taking the trouble to consult types no farther removed from Kew than the rooms of the Linnaean Society in London, and many of the species of Hooker's contemporaries were either discredited without being seen, or entirely passed over in silence. In the cases of Fée, Presl, and Kunze, this was specially pronounced.

Hooker's work ended in 1865 while he was bringing through the press the hand manual of "all known ferns" under the name of *Synopsis Filicum*, which was completed and brought through a second edition by his successor in the fern herbarium. In this work the extreme of conservatism is reached and its nearly three thousand species will expand to over four thousand before even the ferns of the great Kew herbarium of that date are fully enumerated, to say nothing of the two thousand that have been since described and the many that were overlooked by the authors of *Synopsis Filicum.*

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* Volume 17 of *Icones Plantarum*, published however subsequently to Hooker's death, was devoted entirely to ferns.

COLUMBIA UNIVERSITY, October 5, 1904.

[Reprinted from TORREYA, Vol. 5, No. 3, March, 1905.]

THE EARLY WRITERS ON FERNS AND THEIR COLLECTIONS — IV. PRESL, 1794–1852; JOHN SMITH, 1798–1888; FÉE, 1789–1874; AND MOORE, 1821–1887

BY L. M. UNDERWOOD

The real enlargement of the conception of fern genera commenced with Presl and continued with John Smith, Fée and Moore, who were the generic "splitters" in this group of plants. The form of the sporangium had early served to distinguish families, and genera were characterized by the varied distribution of the sporangia over the leaf-surface, combined with the shape of the indusium. Under this method of distinguishing genera Swartz had recognized 38 genera in 1806, and Willdenow 43 in 1810; Desvaux, more liberal, recognized 70 in 1827, and Sprengel the same year found only 66. These numbers were nearly up to the Hookerian standard, for in the *Synopsis Filicum* of 1874 only 76 genera were recognized for the orders Ophioglossales, Marattiales, and Filicales. Contrasted with these numbers, the above-named writers increased the number of fern genera as follows:

Presl,	232 genera.
John Smith,	220 genera.
Fée,	181 genera (Polypodiaceae, only).
Moore,	176 genera.

Karel Boriwog Presl (1794–1852), a native of Bohemia, commenced publication among the ferns in the *Deliciae Pragenses* (1822) and the *Reliquiae Haenkeanae* (1825 *) in which he described numerous species from Brazil, Mexico, Peru, and the Philippines. Then followed his first publication on genera in his

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* The date on the title page of the first volume is 1830, but the work was published in parts, the parts containing the ferns in 1825.

Tentamen Pteridographiae (1836) in which he recognized 116 genera in the Polypodiaceae and Cyatheaceae. This was followed in 1843 by his *Hymenophyllaceae* and in 1845 by his *Supplementum Tentaminis Pteridographiae*, which treated the remaining families. In the former work many new species were described and the *Supplementum* was a monograph of the families Ophioglossaceae, Marattiaceae, Osmundaceae, and Schizaeaceae. His later works were *Die Gefässbündel im Stipes der Farrn* (1847) and *Epimeliae Botanicae* (1849), in which, besides describing many new species, he established 68 additional genera, bringing the total number recognized by him to 232. Presl was among the first to recognize the distribution of the fibro-vascular system both in the stem and in the leaf as having primary importance in the matter of relationship among ferns, and after Robert Brown, was the first really to look upon a genus of ferns as a natural group of closely allied organisms, instead of a loose assemblage of organisms whose superficial and accidental characters brought them under a cut and dried definition based on artificial resemblances.

Such unnatural and unholy alliances as the groups of species still included in *Gymnogramme*, *Acrostichum*, *Polypodium*, and *Davallia* in the *Synopsis Filicum* of Hooker and Baker, were separated by Presl into much more natural groups, and while he made errors, as might be expected in a pioneer, his system is in many respects the most logical single system that has yet appeared.

Presl's collection of ferns is in the botanical museum of the German University of Prague, although some of his types are at Vienna. The collection lies in its original sheets, dust-covered, unmounted, and unmolested. When we visited the collection in 1903 it was even impossible to consult any of Presl's voluminous writings on ferns in connection with his collection, for the simple reason that the extensive botanical laboratory in Prague did not possess them. With the single exception of a solitary note by Al. Braun there was little to show that any one else had ever consulted the collection since Presl's death, and yet the collection, next to those at Kew, Berlin, and Paris, is probably the most important, abounding in novelties and rich in the types of Presl, for he published no less than four hundred species of pteridophytes.

John Smith (1798–1888) was the curator of the Kew Gardens who built up the splendid collection of living ferns at that establishment. He knew ferns in cultivation better than any man before or since his time, and the genera he established were founded largely on habital characters which in great measure were dependent on the fibro-vascular system, whose importance in taxonomy he also clearly recognized. Besides publishing an enumeration of the ferns of the Philippines, Smith early published an outline of his system of fern classification in *Hooker's Journal of Botany* (**4**: 38–70; 147–198. 1842) and afterwards developed it in his later publications (1) *Cultivated Ferns* (1857), (2) *Ferns British and Foreign* (1866, 2d ed. 1877) and (3) *Historia Filicum* (1875), in which he also reviewed other systems.

Smith's collection is at the British Museum and is interesting as the work of a horticulturist, which like that of a pure morphologist shows underestimation of the value of a herbarium specimen. As Smith described comparatively few species, his collection contains few types.

Antoine Laurent Apollinaire Fée (1789–1874) was professor at Strasbourg so long as that city formed a part of France. His publications on ferns consist mainly (1) of eleven memoirs on ferns, the first four in folio monographing *Antrophyum*, *Vittaria*, and *Acrostichum;* the others are in quarto form and comprise *Genera Filicum* (Memoir 5), descriptions of new species from various parts of the world (memoirs 6, 7, 8, and 10), a list of ferns of Mexico (Memoir 9), and a similar but more pretentious list of the ferns and lycopods of the Antilles (Memoir 11); and (2) *Cryptogames vasculaires du Brésil* (1869), with *Supplement* (1872–73) similarly in quarto and like the memoirs admirably illustrated with lithographic plates. These two series contain a total of 285 quarto or folio plates and illustrate about eight hundred species of ferns.

Fée's collection of ferns once belonged to Dom Pedro II of Brazil, and after the death of that unfortunate monarch became the property of M. Cosson in Paris, in whose admirable herbarium it is now incorporated. Fée's species are largely valid ones, but his work has been discredited by the Hookerian school mostly without having seen Fée's types. With Paris as near London as Washington is near New York, this condition of affairs is positively inexplicable, and absolutely without excuse.

Thomas Moore (1821–1887) commenced the publication of an admirable *Index Filicum* in 1857–63, which contained his fern system (pp. ix–clxii, *pl. 1–84*), and commenced an alphabetical enumeration of ferns and their synonyms (pp. 1–396). Publication unfortunately stopped in the middle of the letter G. The MSS. of the remainder is preserved at Kew with Moore's extensive herbarium, the latter containing a number of types of species published largely in the Gardeners' Chronicle. Many have asked, Why should this not be published now? There are many reasons, and among them either one of two should decide the question in the negative. (1) Over three thousand species of ferns have been published since Moore's publication ceased. It would therefore contain less than half of the known species of ferns and so would be notoriously incomplete. (2) In Moore's time the idea of type localities had not become so all-important in the matter of systematic study of ferns as it has at the present time. No index can be regarded adequate for modern use that does not give, in addition to its citation, the type locality, *i. e.*, the source from which the species was first described.

This brief series of papers would be incomplete did we not refer to one other distinguished fern student, Georg Heinrich Mettenius, (1823–1866) for many years professor at Leipzig. Besides various enumerations of the ferns of various countries like Colombia and New Caledonia, Mettenius published (1) his *Filices Horti Botanici Lipsiensis* (1856), in which he early outlined his rather conservative classification, as he recognized only 72 genera, and, (2) a series of monographs of various genera: *Phegopteris, Cheilanthes, Polypodium, Aspidium,* and *Asplenium*, in his *Ueber einige Farngattungen.* After the untimely death of Mettenius, Kuhn, another brilliant but short-lived German pteridologist, published the *Reliquiae Metteniana* (Linnaea, **35**: 385–394. 1868; **36**: 41–169. 1869), in which some species were unfortunately published of which only imperfect material is in existence, some indeed that Mettenius would certainly never have published on such meager data. Mettenius' collection is now incorporated with the general collection of ferns at Berlin, which is next to Kew the most extensive in the world.

Other centers of interesting fern collections in Europe are those of Copenhagen with Liebmann's Mexican species; Munich, with Martius' Brazilian series; Leipzig, with Kunze's collection; and lastly Madrid with the collection of Cavanilles. Before our fern system has been completed all these and the others discussed in this series of papers must be studied comparatively from the standpoint of type specimens.

The Publications of the Department of Botany, Columbia University, consist of Memoirs in quarto and Contributions in octavo.

The Memoirs already published are:—

Vol. I. **Small.** A Monograph of the North American Species of the Genus *Polygonum.* Pp. 178. 84 plates. 1895. Price, six dollars.

Vol. II. **Rydberg.** A Monograph of the North American Potentilleae. Pp. 224. 112 plates. 1898. Price, six dollars.

The Contributions have now reached the ninth volume.

Vol. I. Nos. 1–25 (1886–1892). Out of print, except Nos. 6, 7, 11, 20. These can be supplied at twenty five cents each, except No. 6, which is one dollar.

Vol. II. Nos. 26–50 (1892–1894). Nos. 26, 28, 29, 32, 33, 34, 36, 39, 44, 48, and 49 are out of print; other numbers can be supplied at twenty five cents each, except No. 35, which is one dollar and a half.

Vol. III. Nos. 51–75 (1894–1895). Nos. 50, 52, 54, 59, 60, and 72 are out of print; others can be supplied at twenty five cents each.

Vol. IV. Nos. 76-100 (1895–1896). Five dollars; single numbers twenty five cents each.

Vol. V. Nos. 101–125 (1896–1897) Five dollars; single numbers twenty five cents, except No. 119 which is fifty cents, and Nos. 101, 109, and 124 which can only be supplied with full volumes.

Vol. VI. Nos. 126–150 (1897–1898). Five dollars. Nos. 133, 136, 146, and 150 can be had only in orders for the complete volume; other numbers, twenty five cents, except Nos. 129 and 143, which are fifty cents each.

Vol. VII. No. 151–175 (1898–1901). Five dollars. Nos. 157 and 158* cannot be furnished separately; other numbers twenty five cents each.

Vol. VIII. No. 176–200 (1901–1902). Five dollars; single numbers twenty five cents, except No. 176 which is fifty cents.

Vol. IX. No. 201—(current).

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* Nos 157 and 158, with the set of eleven papers by Mr. Bicknell on ***Sisyrinchium,*** can be had for one dollar and fifty cents.

Lists of titles of Contributions may be had on application.

LUCIEN M. UNDERWOOD,
Professor of Botany.

COLUMBIA UNIVERSITY,
NEW YORK CITY.

RECEIVED,
OCT 23 1906

CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 215

FURTHER OBSERVATIONS ON TAXODIUM

By ROLAND M. HARPER

NEW YORK
1905

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 32 : 105–115. 1905]

LIBRARY OF THE GRAY HERBARIUM
HARVARD UNIVERSITY.
THE GIFT OF
B. L. Robinson.

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 32: 105–115. 1905.]

Further observations on Taxodium

ROLAND M. HARPER

Since the publication of my paper on *Taxodium distichum* and related species [*] I have spent three more seasons in the coastal plain of Georgia, where I have now had the southeastern representatives of this genus under observation every month in the year except December, and I am now able to present some additional notes on them.

One reviewer of that paper (who is among the foremost of American phytogeographers, but not a professed systematist) has expressed the opinion "that *Taxodium imbricarium* will prove to be merely an ecological variety" of *T. distichum*. If this is the case, then some hundreds if not thousands of long established and universally accepted species will have to be placed in the same category. But the fact that these two species remain perfectly distinct when cultivated in the same soil (as noted on the last page of my previous paper), not to mention the considerable difference in their geographical distribution, ought to dispose of the "ecological variety" question. From all the evidence at hand at the present writing the conclusion is irresistible that *T. imbricarium* is abundantly distinct. The only substantial argument which could be urged against the recognition of this species is the occurrence of trees intermediate (in some characters at least) between it and *T. distichum*. But these are outnumbered a hundred to one (in Georgia at least) by typical and unmistakable specimens of *T. imbricarium*, [†] and should not invalidate the species any more than the intermediate forms in countless other genera do.

My work will doubtless admit of some criticism from a geological standpoint, however. My attention has been called by a geologist friend to the fact that what has been passing under the name of the Lafayette formation in Georgia and some other states is probably divisible into two or three different horizons. One of these may be the Grand Gulf, which has recently been a subject of considerable controversy.* Until geologists have settled this point among themselves I can make no satisfactory corrections in this respect. However, when the whole truth is known these two species of *Taxodium* will surely be found to stand always in some such relation to the superficial formations as I have already indicated, whether my present identification of these formations is correct or not.

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[*] Bull. Torrey Club **29**: 383–399. June, 1902.

[†] I have records of three or four hundred stations in Georgia for *T. imbricarium*, at each of which there may be from ten to several thousand individuals; while the intermediate form I have seen only about twenty times, and never more than a hundred trees at a time.

It is absolutely certain though that *Taxodium distichum* grows directly on the underlying rocks of the coastal plain, as I had excellent opportunity to observe on the Flint River east of Americus in July, 1902, when the water was unusually low for that time of year (see *figure 1*). And similar conditions have doubtless existed for thousands of years, for according to Bibbins † fos-

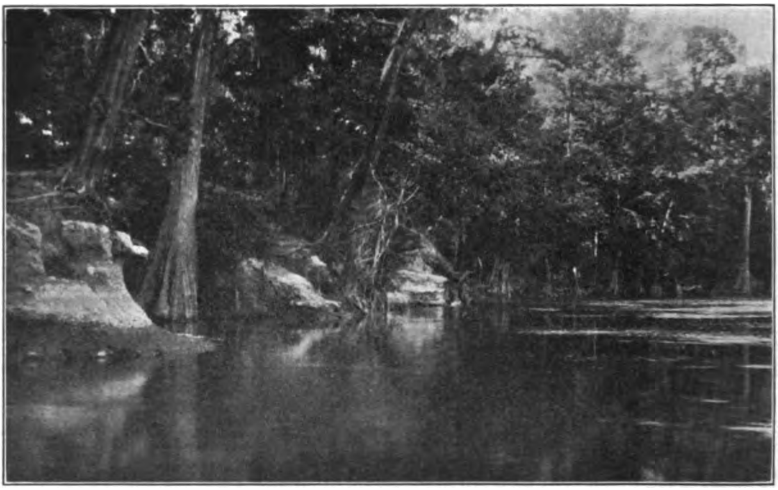

FIGURE 1. *Taxodium distichum* growing on Lower Oligocene rocks on right bank of Flint River, Sumter County. July 5, 1902.

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* For a discussion of the nomenclature, relationships and distribution of this formation the reader is referred to the following papers in Science (new series), all entitled "The Grand Gulf Formation": — Smith & Aldrich, 16: 835–837. November 21, 1902; Dall, 16: 946, 947. December 12, 1902; Smith & Aldrich, 18: 20–26. July 3, 1903; Dall, 18: 83–85. July 17, 1903; Hilgard, 18: 180–182. August 7, 1903.—See also Dall, Trans. Wagner Free Inst. Sci. 3: 1561–1564. 1903.

† Plant World 1: 164–166. August, 1898.

sil cypress stumps have been found on the shores of Chesapeake Bay with their roots imbedded in Cretaceous strata. It was at first supposed that the stumps themselves were of Cretaceous age, but subsequent investigations by the same author and Dr. Hollick have shown that the trees grew in Pleistocene times, sending their roots down into the Cretaceous strata on which they stood, and the stumps have been preserved *in situ*.

The actual contact of *T. imbricarium* with the Lafayette formation (or what passes for it) has not yet been observed, and could hardly be without having special excavations made for the purpose, but I have often seen this formation exposed (particularly in railroad cuts) within a few yards of colonies of this tree.

The relations of the two species under consideration to the geological formations are well illustrated at Bull Head Bluff on the Satilla River in Camden County, Georgia, which I visited in August, 1902. The bluff is about eight feet high, and exhibits the following section, in descending order: Two feet of Columbia sand, five feet of reddish clay (Lafayette?), and about a foot of stiff bluish clay (doubtless Tertiary, but exact age unknown). Typical *Taxodium distichum* grows here along the water's edge, below the Lafayette, while a hundred yards or so away from the river equally typical *T. imbricarium* flourishes in moist pine-barrens.

Ecologists have had a good deal to say recently about drained and undrained swamps, and the remarkable differences in their flora. If they would examine the habitats of the two taxodiums they would find that *T. distichum* always grows in "drained" swamps, and *T. imbricarium* usually in ponds, which are of course "undrained." In the Southeastern States, as in other parts of the country, there are very few species common to both habitats. In their relation to limestone the taxodiums are equally distinct, *T. distichum* being essentially a limestone-loving species and *T. imbricarium* just the opposite. (The latter often, perhaps always, grows over limestone, but never in contact with it, some more recent formation always intervening.)

There are also some additional morphological characters which I overlooked before, by which the two species under consideration may be distinguished. In Washington in the spring of 1902 my attention was called by Dr. J. N. Rose to a difference in the bark of cultivated specimens, that of *T. imbricarium* (cultivated there under the name of *Glyptostrobus*) being considerably thicker and more coarsely ridged than that of *T. distichum*. On my return to the field I soon found that the same was a constant and well-defined character of the wild trees, and it has since been of considerable assistance to me in studying their distribution, particularly in the winter months when the leaves were fallen.

There is also a marked difference in the knees, those of *T. imbricarium* being short and rounded, often almost hemispherical, while those of *T. distichum* are usually slender and acute, sometimes reaching a height of six feet (in the Suwannee River in Clinch County, for instance). The latter species seems to produce knees much more abundantly, Elliott's opinion to the contrary notwithstanding. In both species the height of the knees and that of the enlarged base of the trunk usually indicates the maximum level of the water in which they grow,* with the exceptions that in deep ponds the knees of *T. imbricarium* are entirely submerged or perhaps wanting, and in many creek swamps those of *T. distichum* are very small and do not grow as high as the enlargement of the trunk. In May, 1904, I saw in the pine-barrens near Douglas, Georgia, in a place which had once been a small mill-pond, some saplings of *T. imbricarium* with trunks perceptibly enlarged up to about six feet from the ground, which was just the height of the dam. In cultivation, where they are never inundated, it has been my observation that each species produces a slight but characteristic enlargement of the trunk. (The specimens on the grounds of the Smithsonian Institution and Department of Agriculture in Washington are good examples.) This does not agree with the recently published observations of Dr. S. M. Coulter.† In wet pine-barrens, where there is likewise no inundation, the enlargement of the base of *T. imbricarium*, though insignificant compared with what it is in ponds, is always present (see *figure 4*). In any one stream or pond the enlarged bases are all the same height, regardless of the size of the tree.

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* This was noted in the case of *T. distichum* by Dickeson and Brown in a paper on the cypress timber of Mississippi and Louisiana, in 1848 (Am. Jour. Sci. II. **5**: 15–22).

† Rep. Mo. Bot. Gard. **15**: 59. *pl. 15–18.* 1904.

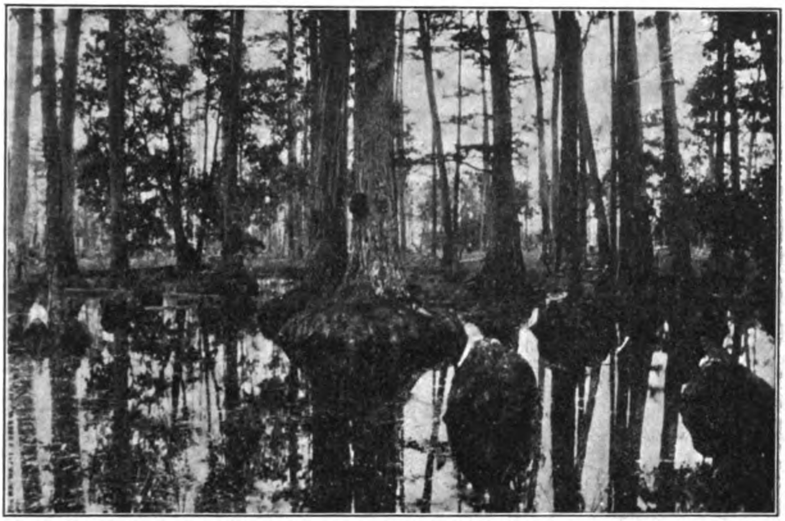

FIGURE 2. *Taxodium imbricarium* in a shallow pine-barren pond in Coffee County. July 24, 1902. Note the rounded knees and the very abrupt enlargement of the trunks. The water-level in this pond probably does not vary more than a foot or two.

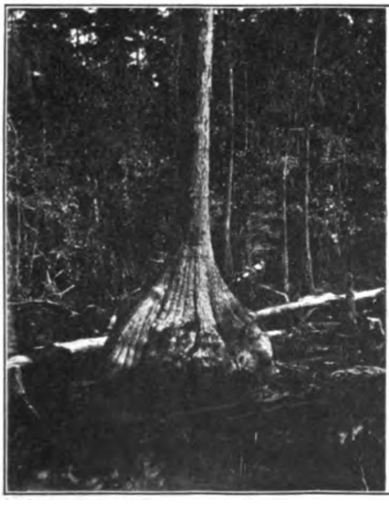

FIGURE 3. *Taxodium imbricarium* in Twenty Mile Creek, Coffee County. Sept. 24, 1900. Note the greatly enlarged base of the trunk and its broad rounded ridges.

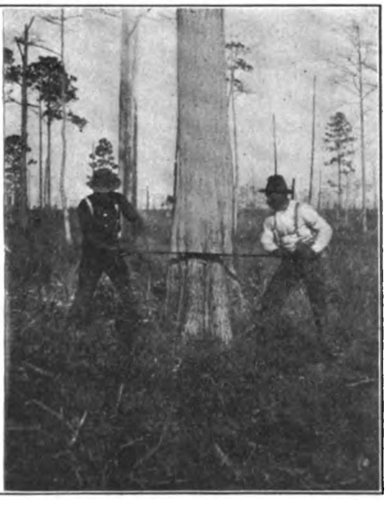

FIGURE 4. *Taxodium imbricarium* in wet pine-barrens near Douglas, Coffee County. Base of trunk not conspicuously enlarged. Several specimens of *Pinus Elliottii* in background. Feb. 3, 1904.

An examination last winter of some specimens of *T. imbricarium* which had been felled, showed the structure of the base of the trunk in cross-section. The broad longitudinal ridges of wood become pressed against each other as they grow, closing the sinuses between them (as shown in the accompanying diagrams), while in *T. distichum* the sinuses are open and rounded and the ridges rather sharp. Ericaceous shrubs (such as *Pieris nitida* and *Leucothoe racemosa*), growing close to the base of such a tree, often have their stems caught in the embrace of the swelling ridges and then appear as if growing out of the *Taxodium* above the ground. The climbing habit of *Pieris phillyreaefolia* * may have originated in some such way. In both species the base seems to be always hollow in old specimens, and knees often grow inside it.

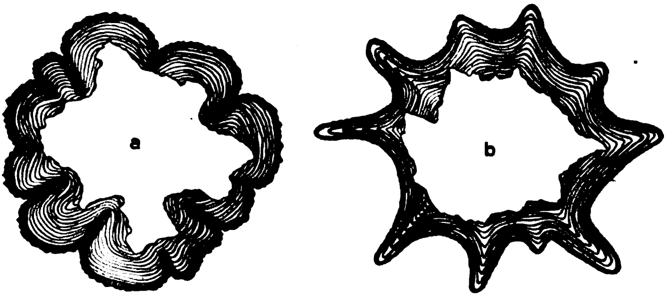

FIGURE 5. Ideal cross-sections of hollow enlarged base of trunk of *Taxodium imbricarium* (*a*) and *T. distichum* (*b*). (The annual rings in reality would be ten to fifty times as numerous as they are shown here.)

Another distinction (though rather a subtle one) between these two species is that in *T. distichum* the trunk is straight but not always erect, while in *T. imbricarium* it is erect but not always straight.

The following additional notes on the distribution of the two southeastern species may be of interest.

TAXODIUM DISTICHUM

In Georgia the inland limit of this species reaches the fall-line at the eastern border of the state, but diverges widely from it westward, following approximately the outcrop of the Eocene formations. On the Savannah River it ascends just to Augusta; on the Ogeechee and its tributaries it terminates somewhere between Louisville in Jefferson County and the Augusta Southern R. R. in Glascock; on the Oconee it is common in Laurens and Montgomery Counties, but terminates at or near the Central R. R. bridge in Washington and Wilkinson; on the Ocmulgee it ascends to Twiggs and Houston Counties; on the Flint to Macon County (I am told), but not quite to the twin cities of Oglethorpe and Montezuma; and on the Chattahoochee I have seen it only in Early County near Saffold, though it grows in low grounds near the river at Columbia, Alabama, several miles farther up. On the smaller rivers which rise below the fall line (and are therefore not muddy), it ascends the Satilla to Bull Head Bluff or beyond, the St. Mary's nearly to its head at the southeastern corner of Okefinokee Swamp, the Withlacoochee to Lowndes County, and the Ochlocknee to Moultrie. (It is mostly in some of these smaller rivers, such as the Canoochee, Ohoopee, Satilla, Suwannee, Allapaha and Withlacoochee, that the puzzling intermediate forms occur.) Near the coast, in the counties of Glynn and Camden in Georgia and Nassau in Florida, this species occurs away from the rivers in numerous extensive swamps, the character of whose flora points strongly to the absence of the Lafayette formation.

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* See Torreya 3: 21, 22. February, 1903.

Its most frequent associates in Georgia are *Hicoria aquatica*, *Planera aquatica*, and *Nyssa aquatica* (*N. uniflora*).

Dr. R. Ellsworth Call* has published some interesting notes on the occurrence of *Taxodium distichum* in eastern Arkansas, in which he says among other things: "From the top of Crowley's Ridge, looking either to the east or the west, at those points which command the valleys of the St. Francis and the Cache, the cypress areas can be readily made out by the observer. The tops of the giant trees tower far above the heads of the intervening forests and give one the location of the swamps for hundreds of square miles."

Some outlying stations for this species in the Edwards Plateau of Texas (which includes Kerrville, mentioned in my previous paper) have been described by Hill and Vaughan,† who say in part: "The occurrence of the cypress is a peculiar anomaly. This tree, which ordinarily grows only in the swamps and bayous of the low subcoastal regions, attains an enormous size at the edge of the deeper holes near the heads of permanent water of the Pedernales . . . and other streams. These localities are at altitudes from 1,000 to 1,750 feet above the sea, hundreds of miles west of the great cypress swamps of the eastern tier of Texan counties, with which they have no possible continuity." (See also Bray, U. S. Dept. Agric., Bureau of Forestry Bull. 47: 53; 49: 16. 1904.)

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* Rep. Geol. Surv. Ark. 1889^2: 198–200. 1891.

† Ann. Rep. U. S. Geol. Surv. 18^2: 210, 211. 1898.

TAXODIUM IMBRICARIUM

This species is very abundant in the coastal plain of Georgia, where I have seen it in every county in which Oligocene or later rocks occur, *i. e.*, from the inland edge of the pine-barrens to Florida and the coast. On the way to Georgia in 1903 I saw it in Moore County, N. C., near the fall-line,* and in Hampton County, S. C. It is common in Nassau and Baker Counties in Florida, but no data are yet available as to its southern limit in that state.

Outside of the pine-barrens in Georgia there are several outlying stations for it, where it grows in shallow ponds. These have been noted as follows: In Richmond County between Adam and Adventure, in Jefferson near Wadley, in Washington near Sandersville, in Taylor near Reynolds, and in Terrell between Bronwood and Dawson. All these localities, according to the best information at present obtainable, seem to be underlaid by rocks of the Claibornian division of the Eocene. The Taylor County station is of interest as being the farthest inland, and most remote from the pine-barrens. At this point the *Taxodium* is in imminent danger of extinction, most of the trees having been already cut and used up (it being apparently the only cypress pond known in the vicinity), and few if any young trees were seen. The principal vegetation of this pond is *Liquidambar*, with a few *Crataegus aestivalis* bushes.

Toward the coast *Taxodium imbricarium* extends nearly to Brunswick, within two or three miles of salt water and not over ten miles from the open ocean. There its habitat and associates are much the same as they are fifty or a hundred miles inland.

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* See Torreya 3: 123. August, 1903.

This turns out to be the predominating tree in Okefinokee Swamp, as already announced,* where it grows in all the sphagnous bogs, with *Pinus Elliottii*, ferns, *Dulichium*, *Eriophorum virginicum*, aroids, orchids, *Drosera*, *Sarracenia*, *Ilex*, ericaceous shrubs, etc., just as several other conifers do in the cedar-swamps and peat-bogs of the North. It is said to attain enormous dimensions there, but I did not penetrate far enough into the heavily timbered portions of the swamp to verify this. Elsewhere in Georgia it is nearly always associated with *Pinus Elliottii*, and commonly with *Pinus serotina*, *Dichromena latifolia*, *Ilex myrtifolia*, *Magnolia glauca*, *Hypericum fasciculatum*, *Nyssa biflora*, *Oxypolis filiformis* and *Pinckneya pubens*.

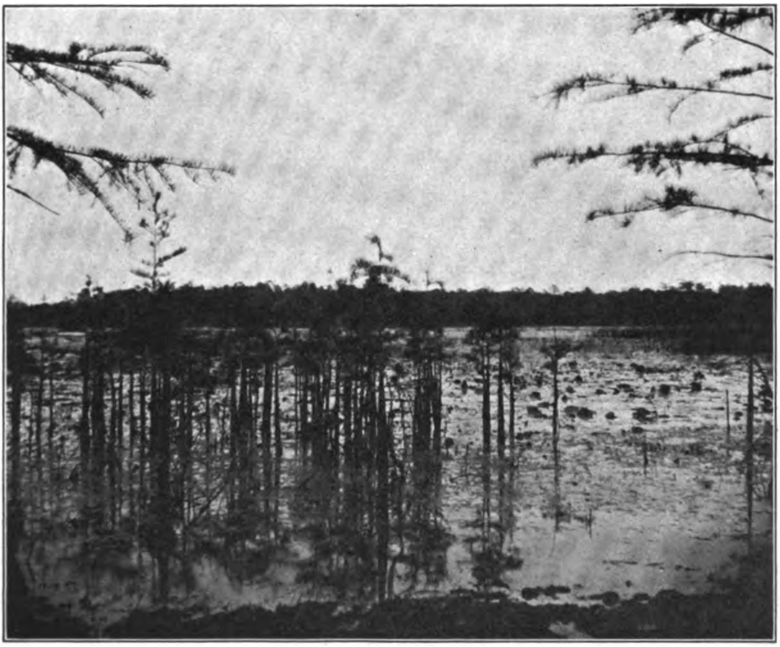

FIGURE 6. View of Cane Water Pond, Decatur County, showing a group of saplings of *Taxodium imbricarium* in center, and branches of two older trees at the sides. Aug 6, 1903. Note the gradually tapering trunks of the saplings (doubtless due to great variations in water-level), and the erect leaf-bearing branchlets on all the trees.

The natives in Georgia do not seem usually to make any dis-

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* See Torreya 2: 157. Oct. 1902; and Science II. 17: 508. 27 March, 1903.

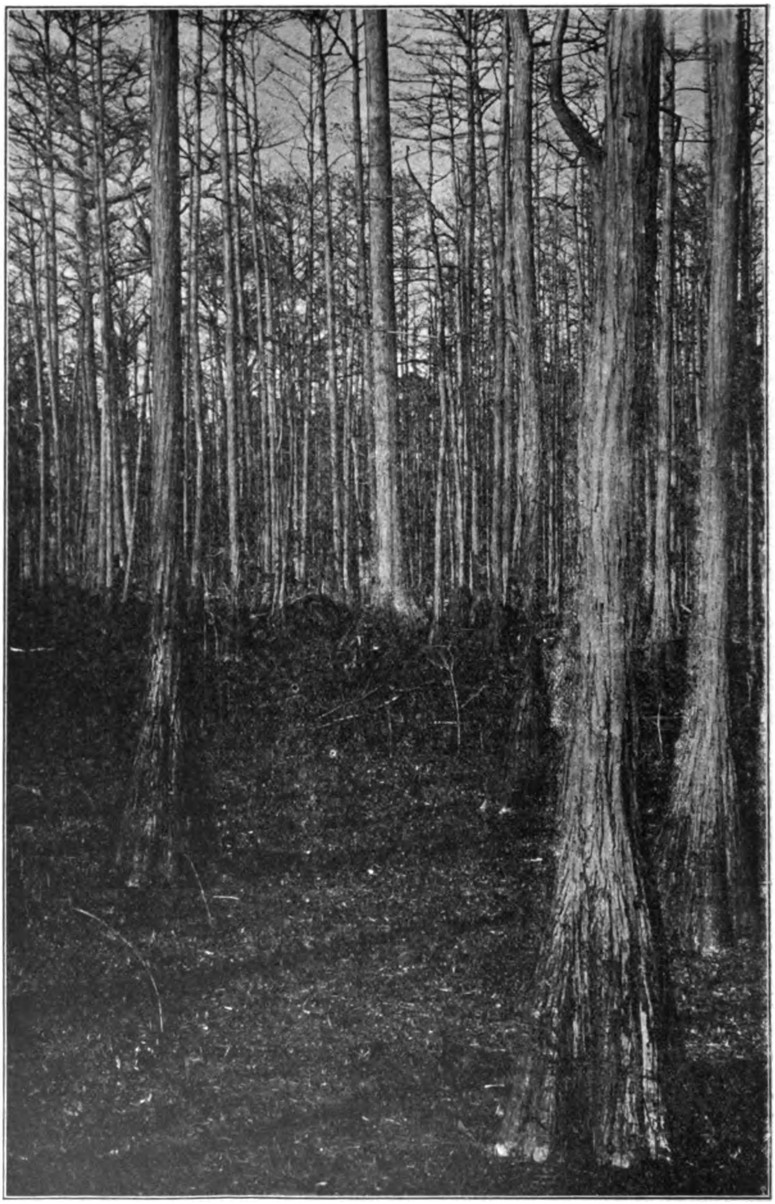

FIGURE 7. Nearly pure association of *Taxodium imbricarium* in a shallow pond (dry at the time the photograph was taken) about three miles east of Valdosta, Lowndes County. Feb. 13, 1904. Note the rather coarsely ridged bark, the erect trunks, and their enlarged bases all of the same height. One or two saplings of *Pinus Elliottii* are visible.

tinction between the two species of cypress. Lumbermen recognize several varieties, such as white, black and red cypress, based on the appearance of the wood, but as they do not correlate these with any leaf or bark characters, I cannot see but what all these names apply to *T. distichum*, which furnishes practically all the cypress lumber on the market. *T. imbricarium* is used to some extent for posts, telegraph poles, and crossties, but just why it is not used for lumber I have not satisfactorily ascertained. Elaborate preparations were made several years ago for getting this species out of Okefinokee Swamp and sawing it up, but for various reasons this enterprise was abandoned after it had been in operation a short time. The danger which thus threatened what is probably the finest body of *Taxodium imbricarium* in existence, which it has taken Nature thousands of years to accumulate, is not altogether past, but may be revived at any time. It is to be hoped that rational methods of lumbering will be universally adopted before the devastation of Okefinokee Swamp is again undertaken.

The illustrations selected to accompany this paper are mostly of *T. imbricarium*, as botanists will be more familiar with the other species, which has often been described and figured. The most conservative should now admit that for phytogeographical purposes at least it is much more desirable to regard the two species here discussed as distinct.

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PHYTOGEOGRAPHICAL EXPLORATIONS IN THE COASTAL PLAIN OF GEORGIA IN 1903

By ROLAND M. HARPER

NEW YORK

1905

[From the Bulletin of the Torrey Botanical Club 32: 141-171. 1905]

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 32: 141-171. 1905.]

Phytogeographical explorations in the coastal plain of Georgia in 1903*

ROLAND M. HARPER

My work in the coastal plain of Georgia in 1903 began on the eastern border of Effingham County, where the Seaboard Air Line crosses the Savannah River, about sunrise on June 12, and ended at Macon on September 25. During the summer notes and collections were made in the following counties: Effingham (nos. *1810–1815*, *1837–1840*), Chatham (*1816–1836*, *1841*, *1842*), Bryan (*1843–1850*), Tattnall (*1851–1862*), Montgomery (*1863–1872*, *1981–1990*), Telfair (*1873*), Dodge (*1874–1876*, *1977–1980*), Wilcox, Dooly (*1955–1964*), Sumter, Lee, Terrell, Randolph (*1877–1898*, *1903*), Quitman (*1899–1902*), Clay, Calhoun, Early (*1904–1914*), Miller (*1915–1919*), Decatur (*1920–1935*), Baker (*1936*), Mitchell (*1937*), Thomas (*1938*, *1939*), Colquitt (*1940–1948*), Dougherty (*1949–1954*), Worth, Berrien, Irwin, Houston (*1965–1967*), Bibb (*1968–1971*), Twiggs, (*1972–1976*), Pulaski, Coffee (*1991–1992*, *2010–2014*), Appling (*1993*, *1994*), Liberty (*1995*, *1996*), Wayne (*1997–1998*, *2007–2009*), Glynn, McIntosh (*1999–2006*), Pierce, and Macon (*2015–2018*). Numbers *1810–1866* were collected in June, *1867–1908* in July, *1909–1958* in August and *1959–2018* in September. Forty-two numbers of fungi and bryophytes, numbered separately, were also collected. During the season I traveled by rail through the coastal plain about 1400 miles (nearly half of which distance was through territory I had not previously explored), and took about 275 photographs.

On this trip I made considerable study of the Altamaha Grit, one of the most interesting (from a phytogeographical standpoint at least) and extensive (covering at least 11,000 square miles) geological formations in the state. Very little work has been done in the region of this formation by other botanists,* and published references to it are scarce.

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* Investigation prosecuted with the aid of a grant from the Herrman Fund of the Council of the Scientific Alliance of New York.

As the Altamaha Grit region (the common name of which, when it is distinguished from other portions of the coastal plain, is the "rolling wire-grass" or "rolling piney-woods" country), by reason of its many natural advantages, which have only comparatively recently begun to be appreciated, is increasing very rapidly in wealth and population,† largely at the expense of its once magnificent pine forests, any information in regard to its flora and other natural resources which can be placed on record now will increase in interest as the region becomes more thickly settled.

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* The younger Bartram and the elder Michaux, whose routes through Georgia in the eighteenth century are pretty well known, could hardly have seen any of the Altamaha Grit region except perhaps the extreme eastern end of it There is evidence that at least some of Abbot's drawings of Georgia plants and insects, published in 1797, were made in this region, but no one knows exactly where. About 1830 Nuttall discovered *Arenaria brevifolia* in Tattnall County, presumably on an outcrop of Altamaha Grit, but very little is known of his movements in Georgia. Croom probably skirted the inland edge of this region on his travels through Georgia during the few years immediately preceding his death, but there is no recognizable description of it in his writings. And since the building of railroads probably as many as a dozen well-known botanists have passed through portions of the Altamaha Grit region, usually without stopping, or ventured into it for short distances, without knowing how it differed from the rest of the coastal plain, but very few of these have made public any notes or specimens from there. It is not surprising, therefore, that I should find new species in that region nearly every season. But for the fact that most of the plants indigenous to that part of the state are not endemic, but extend into the flat country near the coast, or into other states, a much larger proportion of them would still be undescribed.

† The nine counties in Georgia which increased in population over 75 per cent. between 1890 and 1900 are all wire-grass counties, wholly or in part. The three showing the largest increase (Colquitt, Irwin and Tattnall, with percentages of 184, 116 and 99 respectively) are entirely underlaid by the Altamaha Grit. During the same period the whole rolling wire-grass country increased in population over 60 per cent., the whole coastal plain of Georgia 28 per cent., the whole state about 20 per cent., and the whole United States (not counting islands acquired during the decade) about 22 per cent. The average density of population in the Altamaha Grit region in 1900 was about 25 to the square mile and that of the whole state 37.5. Fifty years earlier the region under consideration was regarded as almost a desert, and contained less than four inhabitants to the square mile. Even as late as 1880 the density of its population had not reached ten per square mile.

This region is remarkably free from weeds, mud, dust, floods, droughts, gullies, malaria, and extremes of heat and cold; all of which cannot be said of some other parts of the country. The topography is undulating enough to afford good drainage, and at the same time level enough to offer no serious obstacles to easy transportation (which is so essential for the rapid spread of civilization).

The principal source of wealth for this region has been — and will be for many years, if properly managed — *Pinus palustris*, which is probably at present the most important tree in North America from an economic standpoint, rivaling in the variety and usefulness of its products the classical palms and bamboos of the tropics. Increasing attention, however, is being paid to agriculture and manufactures.

The rock which characterizes this part of the state is not known to contain any recognizable fossils, but it is believed to be of Upper Oligocene age. * It is nearly everywhere concealed by overlying Pleistocene deposits (principally Lafayette and Columbia), but in a few places, usually on slopes in dry pine-barrens, it comes to the surface, forming cliffs or sometimes flat outcrops. Such exposures were seen in 1903 in the counties of Tattnall, Coffee, Dodge and Dooly, and, as might be expected from their scarcity and previously unexplored condition, support a flora of unusual interest. Among the species growing on such rocks are some which seem to be endemic to the Altamaha Grit region, and a still larger number which have been considered as characteristic

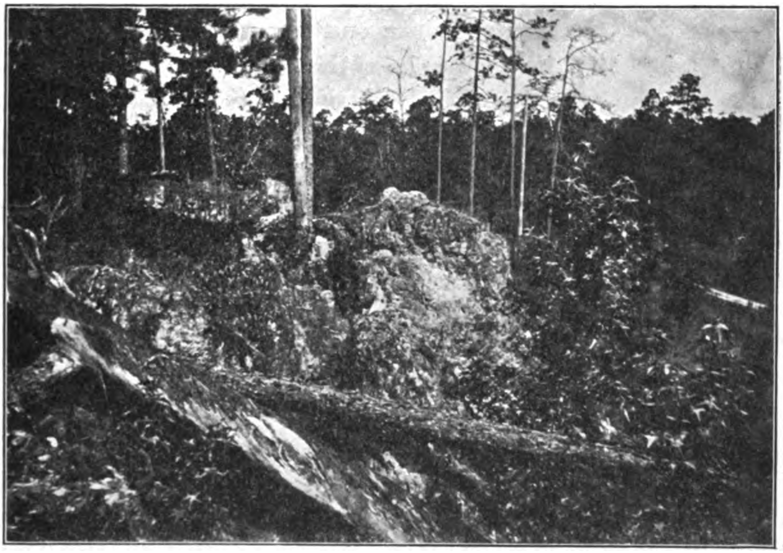

FIGURE 1. Outcrop of Altamaha Grit in open pine-barrens near Pendleton Creek, Tattnall County, June 26. *Liquidambar Styraciflua* in right foreground; the other trees are mostly *Pinus palustris.* This is one of the localities for *Selaginella arenicola* and *Talinum teretifolium*, mentioned below.

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* For description of this formation see Dall & Harris, Bull. U. S. Geol. Surv. 84: 81, 82. 1892.

of granite outcrops in the Piedmont region. Some of them will be discussed in the latter part of this paper.

The ordinary phase of the Altamaha Grit is readily distinguished, as far away as it can be seen, from all other coastal plain rocks by its surroundings and by the appearance of its weathered surfaces, which are just the color of pine bark or perhaps a little darker. (A fresh surface is pale-yellow or often coarsely mottled with red.) Other coastal plain rocks contain more or less calcium carbonate and are surrounded by dense vegetation, but the Grit crops out in broad daylight and is often visible half a mile away.

The Altamaha Grit as such is not known outside of Georgia, though it underlies about one-fifth of the state or a third of the coastal plain, and extends nearly to the Savannah River on the northeast and the Chattahoochee on the southwest. The Grand Gulf, * a formation believed to be of the same age, extends across the lower part of Alabama, Mississippi, Louisiana and Texas, but its actual continuity with our Grit has not yet been established.

The boundary between the rolling wire-grass region (Altamaha Grit) and the lime-sink region (Lower Oligocene) which adjoins it on the northwest in Georgia (and bears a similar relation to the Grand Gulf region in the states farther west), is one of the most trenchant boundaries in the coastal plain, and, when one becomes accustomed to it, is about as easily recognized as the fall-line. † In 1903 I traced this boundary, by crossing it at every convenient point, through the counties of Dodge, Wilcox, Dooly, Worth, Mitchell and Decatur. ‡ A striking feature of this inland edge of the Altahama Grit country, all the way across the state, especially toward the southwest, is that it is marked by

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* Named for Grand Gulf, a settlement on the Mississippi River in Claiborne County, Mississippi, where this formation was first distinguished by B. L. C. Wailes about fifty years ago.

† My first impressions of the change in aspect of the country in passing from one region into the other, traveling southward from Cordele in 1900, were described in the BULLETIN a few years ago (28 : 458. August, 1901). But my interpretation of the geological significance of this change, based on the best information available at that time, subsequent research has shown to be incorrect. (See correction above.) My remarks on *Pinus palustris* in that connection were also largely erroneous.

‡ In the spring of 1904 I traced it farther east, through the counties of Laurens, Emanuel and Screven, nearly to the Savannah River.

an escarpment facing inland, the Grit being everywhere higher than the limestone, doubtless on account of its greater resistance to erosion and solution. In Decatur County, traveling eastward or southward from Bainbridge by rail, one rises about 150 feet in three miles in ascending this escarpment. Elsewhere the difference in elevation is not so great, but always perceptible, as may be seen by examining the profiles of the railroads which pass from one of these regions into the other. From a point on the main Atlantic and Gulf divide a few miles east of Cordele, to the southwestern corner of the state, a distance of at least 100 miles, this escarpment coincides nearly if not exactly with the divide between the Flint River and all the streams flowing into the Gulf east of it.

A similar escarpment is said to mark the inland edge of the corresponding Grand Gulf region in Mississippi and Louisiana.[*] I am also informed by Dr. Eugene A. Smith, who is familiar with the Grand Gulf region of Alabama and Mississippi and has traveled through the Altamaha Grit region of Georgia, that the topography and flora are essentially the same in both. In 1846, some years before the Grand Gulf formation was named, Artemas Bigelow [†] described and figured some rock outcrops in Baldwin County, Alabama (now mapped by Dr. Smith as being in the Grand Gulf region), which must be very similar to the Altamaha Grit outcrops in Georgia. That portion of Alabama is described by Dr. Mohr in his "Plant Life of Alabama" [‡] under the name of "lower division of the coast pine belt," but without emphasizing its geological significance.

The southeastern limit of the Altamaha Grit is ill-defined, for the rolling pine-barrens seem to pass by imperceptible gradations into the flat pine-barrens near the coast. Midway between the Savannah River and the Chattahoochee the region under consideration is at least sixty miles wide; but in the vicinity of Climax, in Decatur County, where its limits are pretty sharply defined, its width is not over six miles, and it probably tapers down to nothing a little farther on.

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[*] See Hilgard, Am. Jour. Sci. III. **2**: 397. 1871; III. **22**: 59. 1881: Dall & Harris, Bull. U. S. Geol. Surv. **84**: 161, 168. 1892; Harris & Veatch, Rep. Geol. La. **1899**: 96. 1900; Veatch, Rep. Geol. La. **1900–02**: 156. 1902.

[†] Am. Jour. Sci. II. **2**: 419–422.

[‡] Contr. U. S. Nat. Herb. **6**: 110–118. 1904.

The typical topography of this region (as is finely displayed around Tifton, for example) is gently rolling, less so of course than in Middle Georgia, but decidedly more so than in the adjoining lime-sink region. A straight line drawn in any direction across the rolling wire-grass country would cross, on the average, two or three valleys to the mile, the bottom of each valley containing a sluggish and often intermittent stream, the water of which is never muddy but usually tinged with brown from vegetable matter. The average difference in elevation between the smaller valleys and the adjacent ridges is probably twenty or thirty feet. Creeks and rivers are of course encountered at longer intervals.

Probably at least nine-tenths of this region, in its natural condition, is pine-barrens, and the remainder is mostly swamps, which border every stream, and sand-hills, which occur along most of the creeks and rivers. The lime-sink region, in Southwest Georgia at least, is also about nine-tenths pine-barrens, the remainder being mostly river-swamps, ponds and lime-sinks. Streams are as scarce in the lime-sink region as they are numerous in the Altamaha Grit country. In August, 1903, I went on foot from Bainbridge (on the Flint River) west to the Chattahoochee, a distance of about twenty-eight miles, and did not see a stream of any kind between the two rivers except Spring Creek, which rises in the Eocene country about thirty miles to the northward.

Ponds are less frequent in the region under consideration than in some other parts of the coastal plain, and those that do occur are almost invariably shallow enough to dry up every year, and full of trees (principally *Pinus Elliottii*, *Taxodium imbricarium*, and *Nyssa biflora*); never containing a dense growth of glumaceous plants (such as *Manisuris Chapmani*, *Panicum digitarioides*, *Homalocenchrus hexandrus*, *Eleocharis*, *Dichromena*, *Rhynchospora*) or shrubs (*Crataegus aestivalis*, *Hypericum fasciculatum*, *Cephalanthus*), like many of those along the inland edge of the lime-sink region, or deep and permanent enough to contain species of *Potamogeton*, *Utricularia* and various *Nymphaeaceae*, like the large ponds of Decatur and Lowndes counties. Another interesting feature of this region is that it contains nearly all the sand-hills of the coastal plain, with the exception of those along the fall-line.

The following species are common and conspicuous in the

Altamaha Grit region, but unknown in the adjacent lime-sink region: *Pinus serotina*,*† *Sarracenia flava*,‡ *Cliftonia monophylla*,§ *Nyssa Ogeche*,†§ *Pinckneya pubens*,*†§ *Viburnum nudum*,* and *Baldwinia atropurpurea*.†‖ Many others having a similar distribution might be mentioned, but the above are of particular interest because they extend right up to the edge of the region, and are easily recognized from a moving train, enabling the observant traveler to tell in a few minutes when he enters the Altamaha Grit country from the north or west.

On the other hand, many species which are common in other parts of the coastal plain are conspicuous by their absence in the wiregrass country. The following grow both north and south of the region under consideration, sometimes approaching within a mile of it, but are not known within its borders: *Phegopteris hexagonoptera*, *Uvularia perfoliata*, *Fagus Americana* (and therefore *Epiphegus* too), *Sassafras*, *Kalmia latifolia*, *Asclepias variegata*, and *Conopholis*. The same is true of several species confined to limestone outcrops or permanent ponds, which it would be superflous to mention here. Again, several river-bank trees, such as *Populus deltoides*, *Platanus*, *Acer saccharinum* (*A. dasycarpum*), *Negundo* and *Catalpa*, descend the larger streams nearly or quite to the Altamaha Grit and seem to stop there. And there is a considerable number of species which range from the mountains to the inland edge of the Grit and no farther, but these are too numerous to be discussed here. When the whole truth is known the Altamaha Grit escarpment will probably be found to stop as many species of plants as the fall-line does, though not for the same reasons.

Of the points of interest visited in the summer of 1903 only a few need be mentioned here.

On the morning of my arrival in Georgia, after following down the Savannah River a few miles from the point where I crossed it, I found myself at Sisters' Ferry, where William Bartram crossed the river on April 25, 1776,* and André Michaux and his son on April 26, 1787.†

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* Reappears northwest of the lime-sink region.

† Not known in Alabama. There is probably a gap between the Altamaha Grit and Grand Gulf regions which these species have not succeeded in crossing.

‡ In Georgia the distribution of this species coincides pretty closely with that of the Grit. But in Virginia and the Carolinas it is found farther inland.

§ Reaches its northeastern limit in the extreme southern corner of South Carolina.

‖ Not known in South Carolina (in which State nothing corresponding to the Altamaha Grit has yet been reported).

Bartram mentioned particularly the occurrence of *Dirca palustris* on the Georgia bank at this point, and Michaux noted, besides the *Dirca*, *Kalmia latifolia*, two azaleas and a few other shrubs. I had no difficulty in finding the *Dirca* and *Kalmia*, and secured specimens of them (nos. *1815*, *1814*). Both species are very rare so near the coast in this latitude and at so low an altitude (probably not over 50 feet above sea-level). At that time I was not aware of Michaux's visit, and I did not notice the azaleas (which must have been past flowering then) and other plants mentioned by him, one of which seems to have been the recently

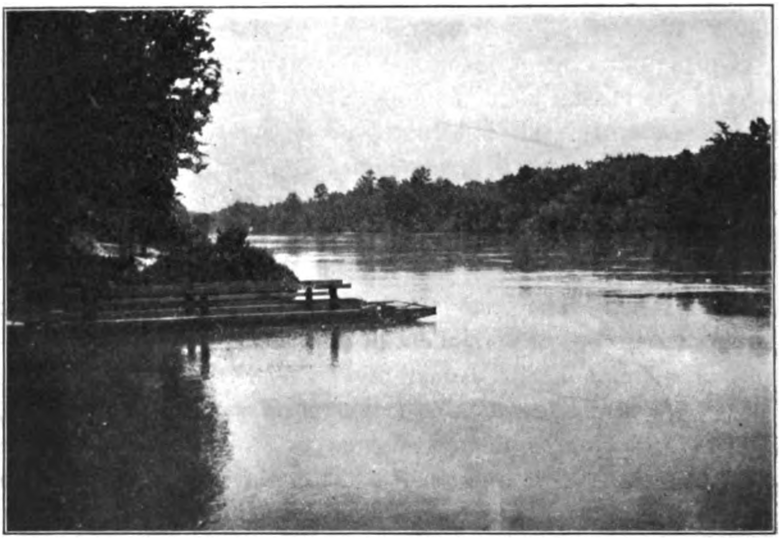

FIGURE 2. Sisters' Ferry, on the Savannah River (Effingham Co., Georgia, and Hampton Co., South Carolina), looking upstream from the Georgia side. June 12. This is the place where Bartram and Michaux crossed in the eighteenth century.

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* See Bartram's Travels, page 307 (of 1794 edition). The year may have been 1777; for the dates in different parts of this work contradict each other, and I have not yet determined which are correct.

† Journal of André Michaux (edited by C. S. Sargent), page 9. On page 12 is a reference to a subsequent visit to the place on May 13 of the same year.

revived *Magnolia pyramidata* Pursh.* The geographical features of the vicinity of Sisters' Ferry, and in fact the whole east side of Effingham County, are rather peculiar, recalling those of the Chattahoochee region of Decatur and Thomas counties. But nothing definite is known about the geology of this county, and the high water prevented me from getting much light on the subject from the rocks along the river.†

On July 31 I discovered something previously unknown to science and entirely unexpected, viz., sand-hills on the Chattahoochee River. These are located on the left or Georgia side in Early County near Hilton. At all other easily accessible points on the Chattahoochee there is not the slightest suggestion of sand-hills, and I was informed that this particular area is only four or five miles long. Where I crossed it it is about a mile and a half wide. These sand-hills have the same general appearance as many of those in Southeast Georgia, but their flora is not nearly so rich in species, which is just what would be expected from their remoteness from other similar areas.

About the middle of August I went to River Junction, Florida, about two miles south of the Georgia line, examined *Tumion taxifolium* ‡ in its native haunts near there, and then spent nearly two days walking up along the Flint River to Bainbridge, a distance of about thirty miles, trying to find this rare tree in Georgia. In this particular I was unsuccessful, but the trip was by no means unprofitable. In this extreme southwestern corner of the state the phytogeographical features are rather complicated, and therefore interesting, but my time there was too short to make more than a superficial examination.

For the last fifteen miles of its course the Flint River (whose junction with the Chattahoochee marks the corner of the state) washes the northwestern base of an escarpment which is nearly 200 feet high in some places. This is a direct continuation of the

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* See Small, Fl. S. E. States 452. July, 1903; Sargent, Trees and Shrubs 1: 101, *pl. 51.* November, 1903.

† This was just after one of the most disastrous floods ever known in South Carolina, and the Savannah River at this point was then nine feet above low water mark and still rising. I noticed however some fossiliferous rocks just above the water's edge.

‡ The odor of the bruised foliage of this tree is frequently mentioned, but I have never seen it described. It reminded me of the odor of the foliage of *Lycopersicum* more than anything else.

Altamaha Grit escarpment mentioned above, but down here in Decatur County, if not for some distance farther east, its base seems to be composed of rocks of a different formation, apparently the Chattahoochee.* The slopes next to the river support a fine forest of angiospermous trees, as is characteristic of the Chattahoochee region. (The transition from the shady woods of the slopes to the open pine-barrens of the summit is very abrupt at Climax and Fowlstown.) At some points along the brow of the escarpment near the river, where the forest has been partly removed, one can get a surprisingly extensive view of the much lower and comparatively level country across the river to the northwestward. At such points the horizon in that direction is so distant that it appears to the unaided eye as a perfect, unbroken, straight line, though doubtless composed of the tops of pine trees.

On top of this escarpment near the Flint River, particularly in the vicinity of Faceville, many square miles are covered with a thick deposit of dry Columbia sand. This supports a flora similar to that of the sand-hills of Southeast Georgia, but differs from all regular sand-hills in its unusual height above the river. It is like the majority of them, however, in being within the Altamaha Grit region, and on the left side of the stream.

Some maps of Georgia show in the northern part of Appling County a pond, which if it is as large as represented must be quite unlike anything else in the Altamaha Grit region. On September 12th, as I was passing through the county, I spent a few hours between trains in trying to find out something about this place. Getting off at Prentiss, the nearest station, I directed my steps northeastward, and after traveling a couple of hours through flat pine-barrens I approached my destination. But I found the pond surrounded by such a dense growth of evergreen trees and shrubs (such as *Magnolia glauca*, *Gordonia*, *Cliftonia*, and *Pieris nitida*) that I could not get a glimpse of it; and the few natives living in the vicinity do not seem to know much about it, and have not even given it a name, apparently. But from the nature of its surroundings and other considerations, I imagine that this pond must be a good deal like Okefinokee Swamp, on a small scale. Within a mile of the pond the sand is deeper and drier than usual, with a sort of sand-hill flora much like that around the large ponds in the lime-sink regions of Decatur and Lowndes counties.*

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* The portion of this escarpment in Decatur County has been described by Pumpelly (Am. Jour. Sci. III. 46: 445–448. December, 1893) and Foerste (Am. Jour. Sci. III. 48: 41–54. July, 1894), but neither of these authors seems to have indicated the occurrence of Altamaha Grit on top of it. I have seen no rocks of this formation farther west than Worth County, but its characteristic topography and flora extend uninterruptedly and unmistakably well into Decatur County. Moreover, the rocks of the Chattahoochee formation are not hard enough to form such an escarpment.

Later in September I did some work along the Altamaha River, in the vicinity of the two points where railroads cross it (near Doctortown and Barrington) and around Darien, the seaport at its mouth. Like most of its tributaries, the Altamaha has sand-hills along its left bank, but they are not as extensive (where I saw them, at least) as those farther inland, and their flora seems less varied. Opposite Doctortown the sand-hills are not over a mile wide, near Barrington (station) they are much narrower, and they disappear entirely somewhere above Darien. At both points where I crossed the river its swamp is about a mile wide, containing several elongated "lakes" (bayous they would probably be called farther west), and happens to be all on the left or sand-hill side. The bridge near Barrington is not over twenty miles from the ocean, but the volume of flow of the river is such that the influence of the sea is not felt by the vegetation there, and I was informed that the tide is perceptible only when the river is very low. (The smaller rivers, such as the Ogeechee, Satilla and St. Mary's, at this distance from the coast have several feet of tide and are bordered by brackish marshes.) Even at Darien, which is within ten miles of the open ocean, the river marshes are fresh or nearly so, and contain a good deal of *Taxodium distichum*. Coming up by steamer from Brunswick to Darien the gradual transition from salt to fresh marshes can be plainly seen, the composition of the vegetation changing almost completely while its general aspect remains about the same.

A few miles above the railroad bridge near Barrington is the lowest ferry on the Altamaha, where the Bartrams, father and son, crossed in the 18th century, and discovered that now long-lost tree, *Franklinia Alatamaha* or *Gordonia pubescens*, as it is variously called.† Somewhere near the same point *Leitneria floridana* was found by C. L. Boynton in July, 1901.* My itinerary did not bring me within sight of either of these rare plants, however.

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*See Bull. Torrey Club 30: 291. 1903; 31: 15. 1904.

† For an account of several attempts to rediscover this tree see Ravenel, Am. Nat. 16: 235-238. 1882.

The new species resulting from this trip which have been recognized up to the present writing all happen to belong to groups with which other persons are more familiar than myself, so none are described in this paper. Among the lower cryptogams one moss has already been described by Cardot,† another by Warnstorf,‡ and a fungus by Dr. Murrill. § The first is based on two collections from the lime-sink region, one made in 1902 and one in 1903; and the other two new species are each based on a single collection from the Altamaha Grit region.

Among the pteridophytes and spermatophytes collected in 1903 the following seem worthy of notice:

SELAGINELLA ARENICOLA Underw. Bull. Torrey Club **25**: 541. 1898

Previously known only from Columbia sand in Florida, and Decatur County, Georgia. I have seen it only on Altamaha Grit outcrops in Tattnall County (*nos. 1854, 1860*), where it is quite scarce.

SELAGINELLA ACANTHONOTA Underw. Torreya **2**: 172. 1902

On driest sand hills in Tattnall (*no. 1852*), Montgomery (*no. 1987*) and Liberty counties. A form not quite typical, approaching *S. rupestris*, was collected on an Altamaha Grit outcrop in Dooly County (*no. 1957*). This species was previously known only from North Carolina, unless some Florida specimens are to be referred to it.

SAGITTARIA NATANS Michx.

In shallow grassy pools just west of Savannah, all submersed but the flowers, June 17 (*no. 1831*). This species has an interesting contrivance for protecting its reproductive organs from water. Whenever by any cause the inflorescence is drawn beneath the surface, the pressure of the water causes each flower to shut up immediately, enclosing a large bubble of air which keeps the interior dry, and at the same time gives the flower buoyancy to rise to the surface again. This perhaps does not happen often in nature, but the experiment may be performed repeatedly with the same flower.*

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* See Biltmore Bot. Stud. **1**: 143. 1902.

† Rev. Bryol. **31**: 8. 1904.

‡ Bot. Centrabl. Beihefte **16**: 250. 1904.

§ Bull. Torrey Club **31**: 600. 1904.

ARISTIDA CONDENSATA Chapm.

Collected on Sept. 10 on the sand-hills of Gum Swamp Creek on the western border of Montgomery County (*no. 1982*), and seen later in the same month on the sand-hills of the Altamaha River in Liberty and McIntosh counties, and of the Little Satilla in Wayne County near Hortense. Previously reported only from Florida.

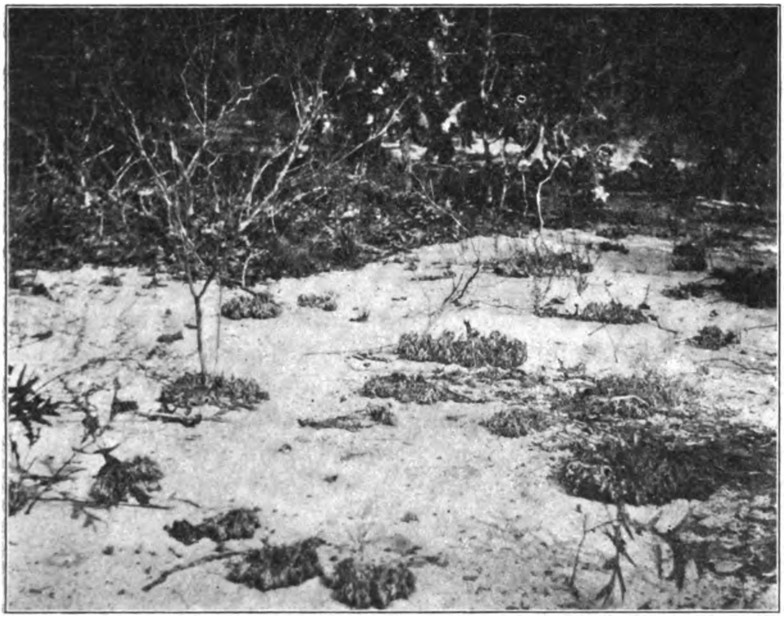

FIGURE 3. *Selaginella acanthonota* (*no. 1987*) on sand-hills of Little Ocmulgee River, Sept. 10. Photograph taken in dry weather, when the stems were all more or less incurved.

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* Since the above was written I notice that the same observation has already been made by Professor Hitchcock (Proc. Iowa Acad. Sci. 9: 215. 1902). But as his note is likely to be overlooked this may as well stand.

FIMBRISTYLIS DIPHYLLA (Retz) Vahl, Enum. 2: 289. 1806

Common along moist sandy roadsides in and near the swamp of Big Indian Creek on the road from Hayneville to Perry, Houston County, Sept. 3 (*no. 1967*). Also seen the next day in similar situations east of Mossy Creek on the road from Perry to Kathleen, in the same county. This is a tropical species, not previously reported from the United States. Dr. Britton, who identified it, tells me that in the West Indies it is principally a roadside weed also, so that its native habitat is more or less problematical. It is rather remarkable that it should penetrate 200 miles into the interior of Georgia, and establish itself in such localities as the above, several miles from any railroad or settlement, before being detected. What seems to be the same thing was collected on a moist exposed grassy bank at the edge of the Altamaha River marshes just below Darien, two weeks later (*no. 2004*). Its occurrence at this seaport is not so surprising, but even there it appeared to have been long established, and should have been seen before.

LUZULA SALTUENSIS Fernald, Rhodora 5: 195. 1903

(*L. vernalis*, *L. pilosa* and *Juncoides pilosum* of American authors.)

Seen in rich shady woods on a north slope a few miles northwest of Cuthbert, July 21. Quite rare. This discovery extends its known range about 150 miles southward, and well into the coastal plain. (The opportunity to combine the new specific name with the other generic name now in use will probably not long be neglected, but in the meanwhile we prefer to use the name as above.)

ALETRIS LUTEA Small, Bull. N. Y. Bot. Gard. 1: 278. 1899

This plant has the aspect of *A. farinosa* with flowers colored almost like those of *A. aurea*. Besides its individual characters (*i. e.*, such as might be exhibited by a single specimen without a label), it differs from the former in range and from the latter in time of flowering, being a month or two earlier. I collected it on June 15 in rather dry pine barrens near Sandfly, Chatham County (*no. 1828*). It was not previously known north of Florida.

CANNA FLACCIDA Salisb.

Like several other species confined to the southeastern United States, this has been greatly neglected by modern bibliographers.

In trying to verify some of the citations for it I found to my surprise that it had been described at least thirty times, and figured eight or ten times. Its bibliographic history is somewhat involved. The principal descriptions, in chronological order, are as follows:

Cannacorus glaucophyllos (etc.), Dill. Hort. Elth. 69. *pl. 59.* 1732. Type locality: "si bene memini, . . . e Carolina, ubi sponte nascitur."

Canna glauca L. Sp. Pl. 1. 1753 (in part). Type locality: "In Carolina?"

? C. glauca L.; Lam. Encyc. 1: 357. 1783. Locality: "dans les lieux humides de la Carolina: on la cultive au Jardin du Roi."

C. flaccida Salisb. Ic. Stirp. Rar. 3. *pl. 2.* 1791. Type locality: "Sponte nascentem in *South Carolina* legit *Johannes Bartram.*"

? C. flava Michx.; Lam. Jour. Hist. Nat. Par. 1: 416. 1792. (*Fide* Ind. Kew.)

C. flaccida Salisb.; Mill. Gard. Dict. (ed. Martyn). 1797. The editor says among other things "It is often confounded with *Canna glauca.*"

C. glauca β flaccida Willd. Sp. Pl. 1: 4. 1798. Locality: "in Carolinae aquosis."

C. flaccida Salisb.; Redouté, Les Liliacées 2: *pl. 107.* 1805. (Specimen figured was cultivated at Malmaison. The author remarks that Fraser and Michaux mention no indigenous *Canna* from Carolina, and as this species is more sensitive to cold than other plants from Carolina, perhaps it came originally from some warmer country. But this is probably explained by the fact that it grows in the extreme southern part of South Carolina, while the other Carolinian plants known to Redouté may have come from the mountains of North Carolina.)

C. flaccida Salisb.; J. E. Smith in Rees Cycl. vol. 6. 1806. "A native of South Carolina, where it was found by Bartram."

C. flaccida Roscoe, Trans. Linn. Soc. 8: 339. 1807. (This is the citation given in the Kew Index.) Type-locality: "Bot. Gard. Liverpool."

C. flaccida Roscoe; Pursh, Fl. Am. Sept. 585. 1814. Locality: "In swamps of South Carolina" (with reference to six earlier descriptions or figures, including Salisbury's and one which I have not seen).

C. flaccida Roscoe; Ell. Bot. S. C. & Ga. 1: 1. 1816. "Grows in wet soils, around ponds; Paris Island, near Beaufort; C[h]atham Co., Georgia."

C. flaccida; Nutt. Gen. 1: 1. 1818. "In Carolina and Georgia."

C. flaccida; Lodd. Bot. Cab. 6: *pl. 562.* 1821. "A native of Carolina and Georgia; we received it about two years since from our valued friend, Dr. Wray of Augusta."

C. flaccida Dill.; Roscoe, Scitamineae (no. 6). 1828. "A native of America, where, Mr. Nuttall informs me, he saw it growing in great quantities on the banks of the Mississippi. Has been cultivated in our gardens many years." (Refers to Dillenius's and Redouté's figures, but not Salisbury's.)

C. Reevesii Lindl. Bot. Reg. 23: *pl.* 2004. 1837. Type-locality: "China."

C. flaccida; Darby, Man. Bot. S. States 247. 1841. "Yellow. May–July. Wet soils. Low country of Car. & Ga. 2–3 feet." (Describes the flowers as red in subsequent editions.)

Eurystylus flaccidus Bouché, Linnaea 18: 485. 1844. (Refers to Salisbury and Willdenow, but mentions no locality.)

Canna flaccida Roscoe; Chapm. Fl. S. States, 466. 1860. (With the longest description in this book and in the three subsequent editions.) Locality: "Miry swamps, Florida and South Carolina, near the coast."

C. flaccida Salisb.; André, Rev. Hort. 1861: 316–320. *f. 79, 80.* 1861.

Eurystylus flaccidus Bouché; Horan. Prodr. Monog. Scit. 18. 1862. Locality: "In paludosis Carolinae australis."

Canna (§ *Corythium*) *flaccida* Roscoe; Wood, Class-Book 692. 1861. "A fine plant, around ponds, S. Car., Ga. and Fla."

C. flaccida Dill.; Regel, Ind. Sem. Hort. Petrop. 1866: 85. 1867. (Unites *C. Reevesii* with *C. flaccida*, probably for the first time.)

C. flaccida; Gray, Field, Forest & Garden Bot. 327. 1869. "Wild in swamps from South Carolina S."

C. flaccida Dill.; B. & H. Gen. Pl. 3^2: 655. 1883. "Species boreali Americana."

C. flaccida Dill.; Petersen in Engler & Prantl, Nat. Pflanzenfam. 2^6: 32. 1889. "Aus dem südlichen Nordamerika."

C. flaccida Salisb.; Petersen in Mart. Fl. Bras. 3^3: 74. *pl. 17. f. 2.* 1890. (Cites a recent Florida specimen, and follows Roscoe in crediting the species to the banks of the Mississippi.)

C. flaccida Salisb.; Baker, Gard. Chron. III. 13: 196. 1893. ("Southern United States; Carolina to Florida, in swamps." Also explains the origin of *C. Reevesii.*)

C. flaccida Salisb.; Bailey, Field, Forest & Garden Bot. 413. 1895; Cycl. Am. Hort. 240. 1900. "Swamps, S. Car. to Fla., near the coast."

C. flaccida Roscoe; Small, Fl. S. E. States 307. 1903. "In swamps near the coast, South Carolina to Florida."

Pursh, Elliott, Chapman, Wood, Small and the Kew Index credit the authorship of the specific name *flaccida* to Roscoe, while Roscoe, Regel, Petersen and Bentham & Hooker credit it to Dillenius, about seven authors credit it to Salisbury, and the remainder do not say where the name originated.

The facts in the case seem to be as follows: Our plant was figured and described in 1732 by Dillenius (but the word *flaccida* does not appear in his polynomial designation), who says the seeds came from Carolina, to the best of his recollection. By Linnaeus it was confounded with *C. glauca*, a very distinct species (if the published figures of it are accurate) of unknown origin. In 1788 Walter reported three species of *Canna* (the same three as in Linnaeus' *Species Plantarum*) from South Carolina, but it is not certain which of his descriptions (if any) applies to the plant in question. In 1791 our plant received its first tenable name from Salisbury, who gave an excellent hand-made colored plate and over a page (a folio page at that) of description. The name *flaccida* was used by at least four other authors before Roscoe, so there is no sufficient reason why it should have ever been credited to him. I have not been able to verify the citation of *C. flava*

Michx., said to have been published in 1792, but there is no *Canna* in Michaux's *Flora*, which appeared eleven years later.

In 1837 Lindley described *C. Reevesii*, from China, saying among other things: "It is very near *C. flaccida*; so very near that it may be doubted whether it is distinct." Baker, in his revision of the genus, states that *C. Reevesii* is genuine *C. flaccida*, cultivated and not native in China, and that the same thing has also been seen in cultivation in the Himalayas.

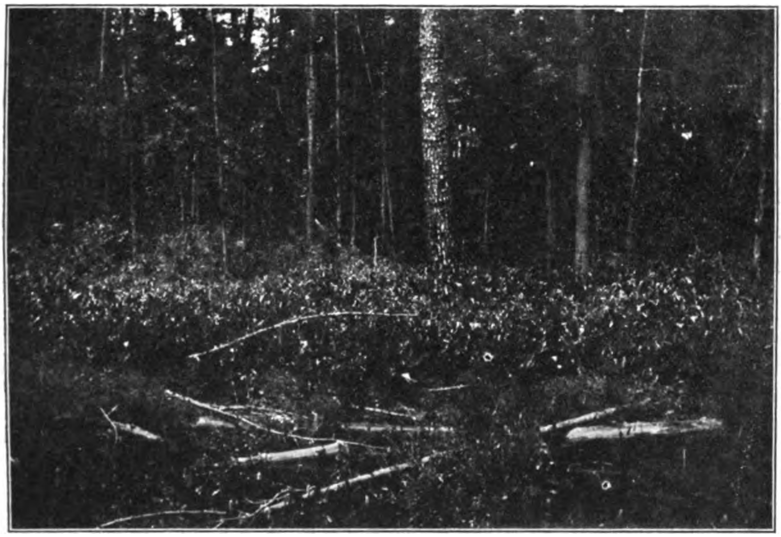

FIGURE 4. Colony of *Canna flaccida*, in low woods in Chatham County, June 13.

In 1844 *Canna flaccida* and the then supposed distinct *C. Reevesii* were made by Bouché the sole representatives of his new genus *Eurystylus*, which does not seem to have been generally adopted. In 1861 Wood, noticing independently the peculiarities of *C. flaccida*, proposed the sectional name *Corythium* for it. It is not surprising that our plant should differ considerably from other species of *Canna*, for they are mostly confined to the tropics, while *C. flaccida* is definitely known only from South Carolina, Georgia and Florida. (But Roscoe says Nuttall found it on the Mississippi; a statement which deserves investigation.)

Whether there are any other native cannas in this country or not is a little uncertain. Walter describes three species, as already noted, and Bartram (*Travels*, page 424) mentions a luxuriant growth of *C. indica* along the Amite River in Louisiana in the 18th century,* at which time one would hardly suppose it could have been an escape. Pursh also mentions *C. angustifolia* L. as having been collected in Georgia by Enslen.

Canna flaccida (or horticultural varieties of it) is often seen in cultivation, but it is not certain how and when it first reached the European gardens from which it has since been distributed. Its occurrence in China early in the 19th century or before is a mystery, unless perhaps it is indigenous there after all, like some other plants of the Eastern United States. Another puzzling thing is that most European authors have described the leaves of this species as glaucous, but this does not seem to be true in the wild state.

In my 1903 collection *Canna flaccida* is represented by *no. 1819*, collected on June 13 in Chatham County about nine miles west of Savannah. At this point it grows abundantly (and often six feet tall) in low woods and even spreads over an adjacent railroad embankment. (There can be no question that it is indigenous there, though.) I saw it from a train at the same place two years before, and in August, 1902, I noted it in Charlton and Camden counties, as well as in the adjoining Nassau County, Florida, where it grows in swamps from which the Lafayette formation seems to be absent, as shown by the occurrence of *Taxodium distichum* and certain other significant plants. The photographs reproduced here are perhaps the first ever taken of this species in a wild state.

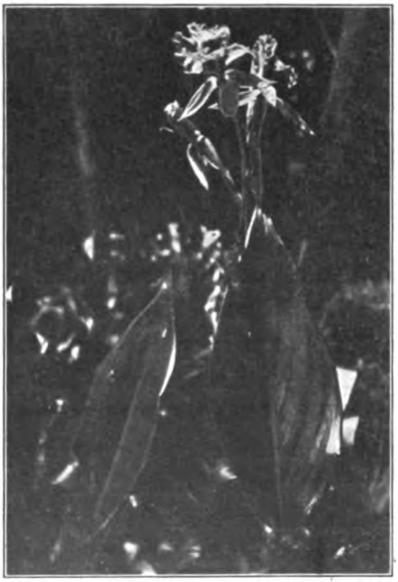

FIGURE 5. Nearer view of a single specimen of *Canna flaccida* (*no. 1819*).

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* *Canna elegans* Raf. (Fl. Lud. 143. 1817) is based on Bartram's description.

EPIDENDRUM CONOPSEUM R.Br.

This, the only epiphytic orchid whose range extends into Georgia, is very hard to find until one becomes acquainted with it, as I know from my own experience and that of some other botanists, and there are few reliable records of its occurrence in the state. Consequently I was agreeably susprised to find it in full bloom near the western corner of Montgomery County on July 3 (*no. 1870*). This locality is about 110 miles from the coast and 200 feet above sea-level. Later in the season I saw it in Dodge County near Eastman, in Dooly County near Cordele, and in Early, Decatur and Thomas counties. The Dooly County station is about 125 miles from the Gulf (the nearest salt water), and 300 feet above sea-level. At all these stations it grew on *Magnolia grandiflora*, and usually high up out of reach. Its preference for this tree was noted long ago by Nuttall, who says in his *Sylva of North America* (**1**: 97): "It appeared there [near Savannah] to grow on no other tree;" as well as by Elliott and perhaps other writers.

POLYGONELLA CROOMII Chapm. Fl. S. States 387. 1860

Type-locality: "In Carolina or Georgia, probably in the middle districts, *Croom*."

I would refer to this little-known species my specimens collected on the sand-hills of Gum Swamp Creek in Montgomery County, September 10 (*no. 1985*). At that time it was just beginning to flower. Ten weeks earlier I had seen the same thing, without flowers, in similiar situations in Tattnall County. It is a diminutive shrub, not over a foot high and wide, and probably lives only a few years.

Dr. Small in his remarks on this genus a few years ago * refers *P. Croomii* to *P. brachystachya* Meisn., a Florida species, and in so doing states that "the labels show that *Polygonella Croomii* is from 'South Florida,' and not from 'Carolina or Georgia' as Dr. Chapman records in the Flora of the Southern United States." This is not strictly correct, however, for the original label (in Chapman's handwriting) says "South Florida?" showing that Chapman was in doubt about the locality, as he had good reason to be, for there is no evidence that Croom was ever in South Florida. It is not unlikely that Croom got his specimens of it on the sand-hills of Brier Creek, on the road from Augusta to Louisville, where he is known to have collected several other interesting plants.

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* Bull. Torrey Club **23**: 407. 1896.

The original specimen is too fragmentary to be of much value for purposes of comparison, but what there is of it seems to be identical with my *no. 1985*. It has longer spikes than *P. brachystachya*, but it is not necessarily specifically distinct. (With this possible exception there is at present no valid species bearing the specific name *Croomii*.)

TALINUM TERETIFOLIUM Pursh

Grows on dry outcrops of Altamaha Grit in the pine-barrens of Tattnall (*no. 1859*, June 26) and Dooly counties, where it seems as much at home as on granite rocks in Middle Georgia. Not previously known from the coastal plain. (It is reported from Florida in Dr. Small's Flora, but I can find no specimens to confirm this.)

PARONYCHIA RIPARIA Chapm.

This species, for a long time known only from the banks of the Flint River in the lime-sink region, now turns out to be not uncommon in Southeast Georgia. In June I saw it more than once in Tattnall County, on July 3 I collected it at the base of the sand-hills of Gum Swamp Creek in Montgomery County, where it was abundant (*no. 1869*), and in September I saw it on both sides of the Ocmulgee River near Lumber City, and on the sand-hills of the Altamaha in Liberty and McIntosh counties.

GIBBESIA RUGELII (Shuttl.) Small

In the Altamaha Grit region near the base of the sand-hills of the Little Ocmulgee River in Montgomery County opposite Lumber City, September 10 (*no. 1990*). Previously known only from Florida and the lime-sink regions of Decatur and Lowndes counties.

CERATOPHYLLUM DEMERSUM L.

On August 27 I found some magnificent but apparently sterile specimens of this (*no. 1952*) growing in a clear cool stream four or five feet deep issuing from a "blue spring" in the Flint River swamp in Dougherty County a few miles below Albany. The plants were often a yard long or more, and presented a beautiful appearance waving to and fro about the white sandy bottom.

Blue springs are common along some of the streams of the lime-sink region, particularly the Flint River, which flows through this region 100 miles or more. They are the outlets of bold subterranean streams, and their bluish color is due to the dissolved limestone. This particular spring, known in the vicinity as *the* Blue Spring, has been visited by several botanists and at least one geologist, and I am informed by the latter that its flow is about 70,000,000 gallons a day.

PODOSTEMON CERATOPHYLLUS Michx.

Collected on August 26 on submerged limestone rocks in very swift water at the shoals of Muckafoonee * Creek near its confluence with the Flint River a mile or two above Albany (*no. 1950*). Not previously reported from the coastal plain. †

The proposed conversion of these remarkable shoals into a source of water-power threatens the destruction of the *Podostemon*.

TIARELLA CORDIFOLIA L.

Observed in rich damp shady woods in Clay County near Fort Gaines on July 23. Rare. This seems to be its southern limit, as far as known. Dr. Mohr ‡ has reported it from Suggsville, Alabama, which is in the same latitude (31°35′), and Wood § mentions its occurrence near Eufaula, Alabama, which is about twenty miles farther north.

CRATAEGUS GEORGIANA Sarg. Bot. Gaz. **33**: 113. 1902; Silva N. Am. **13**: 63. *pl. 649*. 1902.

The only *Crataegus* I collected in 1903 (*no. 1973*) belongs to this species, according to Mr. Beadle, who identified it. It was

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[*] A modern name, coined a few years ago by citizens of Albany for this creek (which is only a mile or two in length) from the names of its two affluents, Muckalee and Kinchafoonee.

[†] An early and little-known record of a Georgia station for this species (in the Paleozoic region) occurs in a paper by Julien Deby, entitled "Relation succinte d'une excursion faite aux bords de l Oostanaula en Géorgie, États-Unis" (Bull. Soc. Malacol. Belg. **12**: (3)-(7). 1877).

[‡] Contr. U. S. Nat. Herb. 6: 534. 1901.

[§] Class-Book 370. 1861.

previously known only from the type-locality, "low meadows, in rich moist soil near Rome," in the Palaeozoic region; but I found it in the swamp of the Ocmulgee River in Twiggs County about a mile above Westlake, on September 7. There it was associated with two palmettos, *Rhapidophyllum Hystrix* and *Sabal Adansonii*, which are of course wanting at the type-locality. But the two localities have at least one feature in common, calcareous soil. My specimens came from a small tree about two inches in diameter and fifteen feet tall.

PETALOSTEMON FEAYI Chapm.

Collected on the sand-hills of the Altamaha River in Liberty County, September 14 (*no. 1995*); mostly past flowering. Previously known only from peninsular Florida. This plant bears a striking resemblance to *Kuhnistera pinnata*, for which it might easily be mistaken when not in flower.

GERANIUM MACULATUM L.

Seen in rich woods at several points in the northern half of Randoph County, July 16, 17 and 18. Apparently not reported from the coastal plain before.

EUPHORBIA FLORIDANA Chapm. Fl. S. States 401. 1860
E. sphaerosperma Shuttl.; Boiss. in DC. Prodr. **15**^{2}: 102. 1862; Ic. Euph. 17. *pl. 54.* 1866.
Tithymalus sphaerospermus Small, Fl. S. E. States 719. 1903.

Collected in dry sand (sand-hills ?) near the Flint River between the state line and Recovery, Decatur County, August 14 (*no. 1931*). Previously known only from Florida and Alabama. (A chance to make a new combination will be noticed in the above synonymy.)

STAPHYLEA TRIFOLIA L.

Fruiting specimens were collected on August 11 on the bank of the Chattahoochee River near Mill Port Landing, Decatur County (just about opposite the southeastern corner of Alabama), in latitude 31° (*no. 1926*). Altitude about 90 feet. The occurrence of this species here was quite a surprise, for it is principally confined to the mountains. The southernmost stations previously known for it were Germain's Island in Columbia County, in the Piedmont region, where I collected it in June, 1902, and the banks of the Chattahoochee in Quitman County, 60 miles north of the present station, where I saw it in October of the same year. In reaching its southern limit on the Chattahoochee River, *Staphylea trifolia* resembles the considerable number of Alleghanian species which extend down to River Junction, about 30 miles farther south. (See Chapman in Bot. Gaz. **10**: 254. 1885.)

TRIADENUM LONGIFOLIUM Small, Bull. Torrey Club **25**: 140, 141. 1898

Collected on September 5 in the muddy swamp of the Ocmulgee River in Bibb County about two miles below Macon (*no. 1971*). Intimately associated with *T. petiolatum*, which it much resembles; but the fact of their growing together without intergrading is pretty good evidence that these two species are distinct. *T. longifolium* was previously known only from the original specimens collected by Rugel in Alabama and Florida in 1843.

To found a new species on a dried specimen which has been accessible to botanists for over half a century is a practice not usually to be commended, but in this case the subsequent developments seem to have justified it.

VIOLA TRIPARTITA GLABERRIMA (Ging.) Harper

Rather common in rich shady woods in Randolph County (*no. 1881*). Although this is said to intergrade with *V. tripartita* in Alabama * and elsewhere, there is no such intergradation in Southwest Georgia, for the simple reason that *V. tripartita* does not grow there, or anywhere else in the coastal plain, as far as known. However, I am not prepared to raise the variety to specific rank.

Mr. Pollard has assumed † that *V. tripartita glaberrima* does not range south of Athens, Georgia, its place being taken farther south by his *V. tenuipes* (a species which I have not yet collected); which assumption was justifiable at that time, no specimens of var. *glaberrima* from South Georgia being then known.

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* Mohr, Contr. U. S. Nat. Herb. **6**: 628. 1901. But Dr. Mohr's statement is inconsistent with other evidence on the same page, for he reports *V. tripartita* only from Lee County (but neither form is mentioned in Earle's later Flora of the Metamorphic Region) and the var. *glaberrima* only from Tuscaloosa County.

† Proc. Biol. Soc. Wash. **15**: 202. 1902.

LYTHRUM CURTISSII Fernald, Bot. Gaz. **33**: 155. 1902

Not rare in the muddy swamp of Spring Creek near Colquitt, Miller County, Aug. 4 (*no. 1918*); also seen on the bank of the same creek near Brinson, Decatur County, eight days later. These two stations are almost in a direct line between the type-locality in Calhoun County and the other station (Aspalaga, Florida) mentioned in the original description.

This species is not mentioned in Koehne's recent monograph of the Lythraceae (Engler's Pflanzenreich, Heft 17. October, 1903).

ERYNGIUM PRAEALTUM Gray, Bost. Jour. Nat. Hist. **6**: 210. 1850. (Pl. Lindh.)

This species has been united by Coulter and Rose with *E. aquaticum* L. (*E. virginianum* Lam.), but it is distinct, certainly varietally if not specifically. On June 18 I collected it for the first time, in the swamp of the Savannah River in the southeastern corner of Effingham County (*no. 1839*). It was not yet in flower, and probably did not begin to flower until July or August. The river was so high at the time* that the plants were about half submerged, and I had to use a boat to get them. My station is within 20 miles of Bluffton, S. C., where Dr. Mellichamp collected the same plant. There is also a specimen in the herbarium of the New York Botanical Garden collected by my friend Mr. M. H. Hopkins in a "marshy spot just below Savannah, Aug. 9, 1897." This station is about the same distance from the two just mentioned as they are from each other.

Dr. Gray's comparison of the leaves of this species to those of a *Rumex* is a very apt one. I mistook the plant for a *Rumex* myself until I saw its budding inflorescence.

Many if not most of the larger leaves bore an appendage the like of which I have never seen described, consisting of what was essentially a smaller leaf 2–6 cm. long, attached near the middle of the upper surface of the true leaf, with its ventral surface facing that of the leaf, its dorsal surface more or less concave, and its midrib adnate for most of its length to that of the leaf. This appendage was too common to be considered a mere monstrosity, but I will not attempt to explain it. I noticed that some insect or spider had woven a dense web in some of the larger appendages, but this may not mean anything.

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* See second footnote on page 149.

ERYNGIUM AROMATICUM Baldw.

In dry sand near Jesup, Wayne County, in flower, September 14 (*no. 1998.*) This extends its known range about 50 miles northward. I found this plant near the Florida line in Charlton and Clinch Counties in August, 1902, but before that it had been known only from Florida. *

The "*Eryngium foetidum* L." mentioned by Michaux and Pursh,† is in all probability *E. aromaticum*, which of course had not then been distinguished, though Michaux must have seen the plant on his travels in northeastern Florida, where it is often collected. Walter also mentioned an *E. foetidum*, the description of which sounds more like what we now call *E. virginianum* Lam. He of course never saw Baldwin's plant, for it does not grow in his territory.

ELLIOTTIA RACEMOSA Muhl.

Since reporting this species from Telfair County,‡ I have found still another station for it, about forty miles farther south, namely, in very dry pine-barrens just north of Douglas, Coffee County, where I collected it on the morning of September 22, long past flowering (*no. 2011*).* None of the plants were over three or four feet tall. *Elliottia* is a very ordinary-looking bush when not in flower, and might easily be mistaken for something else, particularly for *Diospyros virginiana*, a small form of which sometimes grows in similar situations.

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* In the Torrey Herbarium there is a specimen of it labeled "Near Fort King, Alabama. *Lt. Alden*, 1833", and by reason of this specimen it has been credited to Alabama in Coulter and Rose's *Revision* (1888) and *Monograph* (1900) of North American *Umbelliferae*, and in Small's *Flora of the Southeastern States* (1903). But this species is not mentioned in Dr. Mohr's *Plant Life of Alabama* (1901), and on investigating I find that the "Alabama" on the label must be a clerical error. Torrey and Gray were not misled by it, but it seems strange that they did not correct the label. Fort King is (or was) in Marion County, Florida, near the present city of Ocala, and a battle was fought there April 28, 1840, so it is extremely likely that this is the place where Lieut. Alden was stationed in 1833. Further evidence as to the field of Lieut. Alden's botanical operations is found in Torrey and Gray's *Flora of North America*. In the preface (p. xii) they say: "From Southern and Eastern Florida we have received interesting collections from . . . Lieut. ALDEN of the United States Army." (And this gentleman is not mentioned among their contributors from Alabama.) In the same volume under *Eryngium aromaticum* (page 604), they say: "Dry pine woods, East and Middle Florida, *Baldwin! Dr. Leavenworth! Mr. Alden!*" So we have no evidence that *E. aromaticum* grows within 140 miles of Alabama. Errors of this kind usually die hard, so I have gone into considerable detail in order to suppress this one.

† See C. & R. Rev. N. Am. Umbell. 99. 1888; Contr. U. S. Nat. Herb. 7: 250. 1900.

‡ Torreya 3: 106. 1903.

AZALEA CANDIDA Small

Seen only on outcrops of Altamaha Grit, in Tattnall County, June 24 (*no. 1858*) and 26, and in the northeastern corner of Coffee County, September 11. Previously reported only from the type-locality in Lowndes County, but on what formation is not known. At the time I collected it, it was long past flowering; † and the flowers are not yet known, except from a few shrivelled fragments on the type-specimens, which were collected at about the same time of year as mine. This species is probably nearest related to *A. canescens* Mx.

DICERANDRA ODORATISSIMA Harper

Noticed on the sand-hills of the Altamaha River in Liberty County, September 14. Here the corollas were often slightly tinged with pink, making an approach in this respect to the other species of the genus. Captain LeConte's specimen (mentioned in my original description) ‡ may have come from near this place.

PENTSTEMON DISSECTUS Ell.

After having been lost to science for seventy years or so, this species was collected on outcrops of Altamaha Grit near the Ohoopee River in Tattnall County on June 24, in fruit (*no. 1856*), and seen in similar situations in Dooly County on August 29. It has a rather interesting history. It was described by Elliott from specimens sent "from Louisville, Georgia," by James Jackson, § but it is not likely that the specimens were collected close to Louisville, for Mr. M. H. Hopkins, a very observant botanist who has lived in Louisville for years and is familiar with the surrounding country, tells me that he has never seen this plant. But the Altamaha Grit country comes within fifteen miles of Louisville, and if there are any rock outcrops in that part of it, it may have been on one of them that Mr. Jackson found the *Pentstemon*. It was a common practice in Elliott's time (and continues to some extent to the present day, unfortunately) for authors to cite as localities for their specimens merely the nearest town, or the place from which they were sent.

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* On May 11, 1904, I revisited this spot and found that it had just been burned over and the *Elliottia* completely denuded, but most of the specimens were putting out new leaves again.

† On April 26, 1904, I revisited the spot, and it was just past flowering then.

‡ Bull. Torrey Club 28: 479. 1901.

§ This James Jackson, afterward a professor in the University of Georgia, seems to have been a son of the General James Jackson who was governor of Georgia from 1798 to 1801, at which time Louisville was the capital of the state.

Croom* has published the following note on this species: "Abundant in wet Pine woods, between the Oakmulgee and Oconee Rivers,† Georgia. Flowers in May." His statement that it grows in wet places is rather puzzling (unless perhaps he saw it in rainy weather, when everything was wet), for I find it on dry rocks.‡ And I do not quite understand its being abundant, or growing so far inland.

The fruit of *Pentstemon dissectus* has never been described, but it does not differ noticeably from that of *P. hirsutus* (the common species in Georgia).

UTRICULARIA RESUPINATA B. D. Greene

On the miry margin of a large shallow grassy pine-barren pond in the lime-sink region of Decatur County about two miles southwest of Donalsonville, August 11 (*no. 1925*). Not previously reported from Georgia, or from any other southern state except Florida.

STOKESIA LAEVIS (Hill) Greene

This species has the reputation of being rare, therefore the announcement of a station for it in Georgia may be of interest. On September 9 I collected it in moist pine-barrens in Dodge County near Suomi, in the Altamaha Grit region (*no. 1980*). It was already past flowering.

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* Am. Jour. Sci. 25: 76. 1834.

† Doubtless somewhere between the modern cities of Dublin and Hawkinsville, through or near which points Croom is known to have passed.

‡ The same discrepancy exists between the type-habitat and present known habitat of *Gerardia Plukenetii* Ell. See Mohr, Contr. U. S. Nat. Herb. 6: 727. 1901.

CARPHEPHORUS TOMENTOSUS (Michx.) T. & G.

This species seems to have such a limited distribution in Georgia that a few stations for it may be worth mentioning. I have seen it only in rather dry nearly flat pine-barrens in the lower part of the Altahama Grit region or between that and the coast, in the counties of Appling, Wayne and Pierce. In September, when it was in flower, I saw it at the following places. In Appling: near Prentiss (*no. 1993*), and between Southern Pines and Hurst (two stations on the B. & B. R. R.); in Wayne: near Hortense and Nahunta; and in Pierce, between Offerman and Bristol.

CHONDROPHORA VIRGATA (Nutt.) Greene,
Erythea 3: 91. 1895

This little known species has an interesting and rather anomalous distribution and somewhat of a history. The only definite stations for it now on record are in the mountains of Alabama, on Carboniferous sandstone. Its occurrence there has been described or discussed by Mohr,* Kearney † and Harbison ‡; and I have seen an immature specimen collected somewhere in the same region by Eggert. In 1903 I met with it quite unexpectedly in Georgia, two or three hundred miles from the Alabama localities and in very different surroundings from those previously described, but associated with a few of the same species which are said to accompany it in Alabama. I found it only on outcrops of Altamaha Grit, in Tattnall (*no. 1857*) and Dooly (*no. 1855*) counties. At the latter station *C. nudata* (which is very abundant in almost all moist pine-barrens) was growing only a few yards away, but the two species were perfectly distinct, though flowering at the same time. There can be little doubt of the identity of my specimens with those from Alabama, but whether any of these are the same as Nuttall's type is another question, as Dr. Mohr pointed out.

CHRYSOMA PAUCIFLOSCULOSA (Michx.) Greene, Erythea 3: 8. 1895

This, usually considered a sea-beach plant,§ also occurs some distance in the interior. On September 10 I found it at two places on the western border of Montgomery County, on the sand-hills of Gum Swamp Creek (*no. 1986*) and its continuation, the Little Ocmulgee River. The bushes were about a meter tall, and just beginning to flower. In the Torrey Herbarium there is a specimen collected by Croom still farther inland, on the sand-hills of Brier Creek, Georgia (doubtless on the Augusta-Louisville road, near where Richmond, Burke and Jefferson counties meet), and it is mentioned in some of Croom's letters to Torrey.

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* Bull. Torrey Club **24**: 28. 1897; Contr. U. S. Nat. Herb. **6**: 79, 771. 1901.

† Science II. **12**: 833. 30 N 1900.

‡ Biltmore Bot. Stud. **1**: 153. 1902.

§ See Lloyd, Bull. Torrey Club **28**: 445–450. 1901.

ASTER ERYNGIIFOLIUS T. &. G. Fl. N. Am. 2: 502. 1843

Prionopsis Chapmanii T. & G. Fl. N. Am. 2: 245. 1842. Not *Aster Chapmanii* T. & G. Fl. N. Am. 2: 161. 1841.

In moist undulating pine-barrens about a mile east of Recovery, Decatur County, August 14 (*no. 1932*); so rare that I could find only two or three good specimens. This locality is near the extreme southwest end of the Altamaha Grit region. The species has been previously reported only from Florida, but on what formation it is of course not stated.

ANTENNARIA SOLITARIA Rydb.

Abundant at one place in rich shady woods near Cuthbert, July 28 (*no. 1903*). This is the only station known for it in the coastal plain, with the exception of Carpenter's original station in Louisiana,* which probably has not been rediscovered. *A. plantaginifolia*, which I have also never seen farther south, grows in drier places in the same woods.

ACANTHOSPERMUM HISPIDUM DC. Prodr. 5: 522. 1836

Rather abundant in waste places along the river road in the outskirts of Darien, Sept. 16 (*no. 1999*). A native of South America, not previously reported from the United States. It has a very different aspect from its now too common congener *A. australe*, being an erect bushy plant sometimes a meter tall and wide.

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* T. & G. Fl. N. A. 2: 431. 1843. What part of Louisiana is not specified, but a note in Carpenter's handwriting, accompanying the specimen in the Torrey Herbarium, says: "Sides of steep hills, near Jackson, La. Feby. 10th." Jackson (or at least the modern settlement of that name) is in East Feliciana Parish, considerably nearer the coast and farther south than my station, and hundreds of miles from any other known.

A specimen labeled "Ballast ground, Pensacola, Florida," collected by A. H. Curtiss, August 2, 1899 (*no. 6501*, distributed as *A. humile* DC.) is identical with my plant.

HELIANTHUS HETEROPHYLLUS Nutt.

This seems to be quite rare in Georgia. I saw it in September in rather dry pine-barrens near Jesup and Offerman, but not in sufficient quantity to collect.

BALDWINIA ATROPURPUREA Harper

Principally confined to the Altamaha Grit region, but seen also in September, 1903, in the nearly flat pine-barrens of Wayne and Pierce counties, where the Grit may possibly be overlaid by some newer formation. In Wayne County it is quite common, and I secured excellent specimens near Nahunta on the 19th (*no. 2007*). A few days later I found it in two additional counties well within the Grit region, namely, Coffee and Wilcox. Traveling from Douglas to Cordele on the 23d, a distance of about 65 miles through the Altamaha Grit region, I noted this plant seventeen times, between different mile-posts, in four counties. (That such a common, conspicuous and unmistakable plant should have been overlooked until the end of the 19th century is a striking illustration of how little the interior of South Georgia has been explored by botanists.*)

MARSHALLIA RAMOSA Beadle & F. E. Boynton

This recently-described species seems to have considerable variation in habitat. It was discovered in 1900 "in moist, sandy pine-lands at [or near?] Eastman, Georgia." In 1902 I found it in dry pine-barrens in Johnson County,† and in 1903 I found it only on outcrops of Altamaha Grit, in Tattnall (*no. 1855*) and Dodge counties. The latter station is only a couple of miles from Eastman, and therefore somewhere near the type-locality.

MESADENIA DIVERSIFOLIA (T. & G.) Greene

Cacalia diversifolia T. & G. Fl. N. Am. **2**: 435. 1843; Chapm. Fl. S. States 244. 1860. Type-locality (according to Dr. Chapman, the discoverer): "Muddy banks of the Chipola River, [near?] Marianna, West Florida."

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* But that part of the railroad from which these seventeen observations were made did not exist in the summer of 1900, when the species was discovered.

† See Bull. Torrey Club 31: 27. 1904.

Mesadenia difformis Small, Fl. S. E. States 1301. 1903.
Type-locality: Walton County, Florida. (Collected by Curtiss in 1885.)

When I was assisting Dr. Small in preparing a key to *Mesadenia* for his Flora we could find no specimen of *M. diversifolia*, and came very near omitting this species entirely as being too little known. The original specimens, collected by Chapman, must have been lost, as the material so labeled in the Torrey Herbarium represents something very different, and inquiry at the Gray Herbarium failed to reveal anything corresponding to the original description.

But within two weeks after the book was given to the public I unexpectedly received a great deal of new light on the subject. On August 4 I found specimens agreeing exactly with Chapman's description (as far as it goes) in the muddy swamps of Spring Creek at two different places: in Early County near Damascus (*no. 1914*) and in Miller County near Colquitt (*no. 1917*.) A couple of months later I saw in the Biltmore Herbarium a good specimen collected on the muddy banks of the Chipola River near Marianna, Florida (the type-locality, apparently), by C. L. Boynton, August 31, 1899.

One important character can now be added to the descriptions of this species; viz., the involucral bracts have winged keels, as in *M. tuberosa*, *M. Floridana*, and *M. sulcata*. *M. diversifolia* differs from these three species, however, in having the stem merely angled, not furrowed (just as Dr. Chapman indicated), as well as in the lobed upper leaves and in habitat.

M. difformis Small, based on a single immature specimen collected in Walton County, Florida, by A. H. Curtiss in 1885, now proves to be merely a young state of *M. diversifolia*, and must be relegated to synonymy.

As now understood, *Mesadenia diversifolia* has a very restricted range, being known only from Early and Miller counties in Georgia and Jackson and Walton counties in Florida, all of which are wholly or partly in the Lower Oligocene or lime-sink region. It is also to be expected in the intervening counties of Decatur in Georgia and Houston in Alabama.

COLLEGE POINT, NEW YORK.

The Publications of the Department of Botany, Columbia University, consist of Memoirs in quarto and Contributions in octavo.

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CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 217

A SUMMARY OF CHARLES WRIGHT'S EXPLORATIONS IN CUBA

By LUCIEN MARCUS UNDERWOOD

NEW YORK
1905

[From the Bulletin of the Torrey Botanical Club 32: 291-300. June, 1905]

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 32: 291–300, *pl. 21*. 1905.]

A summary of Charles Wright's explorations in Cuba

LUCIEN MARCUS UNDERWOOD

The botanical explorations of Charles Wright in Cuba laid the foundation for our knowledge of the flora of that island, but have left much to be discovered. As will be seen by the following summary, his travels were confined chiefly to the two ends of the island, leaving the great central portion largely unexplored. It is very unfortunate that the labels on his plants, at least in most of the collections where they are to be found, bear only the inscription "Cuba" or "in Cuba orientali." A serial catalogue of Wright's numbers would be of great value, made up from the data on some of the collections where they are to be found. For example, the ferns in Eaton's collection at New Haven bear the data with a much greater degree of fullness, written in from Wright's field-notes, and as Eaton published on the ferns of Wright's collections it is probable that his collection is fuller than any other in existence.* Probably the Grisebach collection of spermatophytes at Göttingen is the most complete for this group, but that of Sauvalle (now at the Estación Central Agronómica in Cuba) is very complete and is said to contain notes showing localities, as would be natural considering the plan Wright had in mind to prepare a flora of the island in connection with Sauvalle.

It appears from Wright's correspondence that a considerable portion of his collection was lost, mainly that collected in the rich tobacco region of the western end of the island (Pinar del Rio). How extensive this loss may have been, probably cannot now be estimated, but it was certainly considerable.† Wright's sojourn in Cuba covered a period of nearly ten years. He arrived in Santiago de Cuba 25 November 1856, and returned to New York 9 September 1857. His second voyage brought him to Santiago 30 November 1858 and he left Havana for New York 28 July 1864. His third trip commenced in May 1865 and he returned in July 1867.

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* Dr. Gray (Am. Jour. Sci. III. 31 : 12. 1886) says that the collection at the Gray Herbarium is "the fullest set," but the ferns at least are better represented at New Haven.

† It seems probable that this loss must have been very great, for we are surprised at the numbers included in his sets. His numbers do not run much above 3,900, and with a flora so large as that of Cuba it seems singular that a professional collector in ten years should not have reached a much higher number, especially as there are numerous duplicates in his collection, at least among the groups of plants with which the writer is mostly concerned. The lower cryptograms were not numbered serially and he

In order to determine more accurately Wright's exact route in Cuba, the writer applied to Miss M. A. Day, the librarian of the Gray herbarium, for information regarding Wright's field notes or other sources of information that might exist at Cambridge. Through her kind intervention, it was made possible to examine the extensive series of letters written by Wright, during his long residence in Cuba, to Dr. Asa Gray. These are now in the possession of Mrs. Gray and it is owing to her generosity that we were able to consult at our pleasure the long series, which consists of some two hundred finely written and often long-continued letters which are full of valuable notes on the flora. The time will come when the publication of these letters, or excerpts from them, will form a valuable commentary on Cuban plants. The tedious perusal of these letters was diversified by Wright's accounts of his experiences, some of which were almost the duplicate of our own, and more especially by the side-notes on the political situation existing in our country during the stormy and tumultuous period of the Civil War (1861–1865). It would appear that Wright was a northern Democrat, and his previous travels in the South had led him to understand the problem from a broader standpoint than many of the residents of New England, whose bias was in great measure due to this lack of exact information of the real situation, and his vigorous statements were evidently called forth by equally strong sentiments from his correspondent.

As we are concerned at present only with the matter of Wright's itinerary, we will cite only the dates and localities where the letters were written, with sufficient of the context to explain the locality and the direction of the course of exploration.

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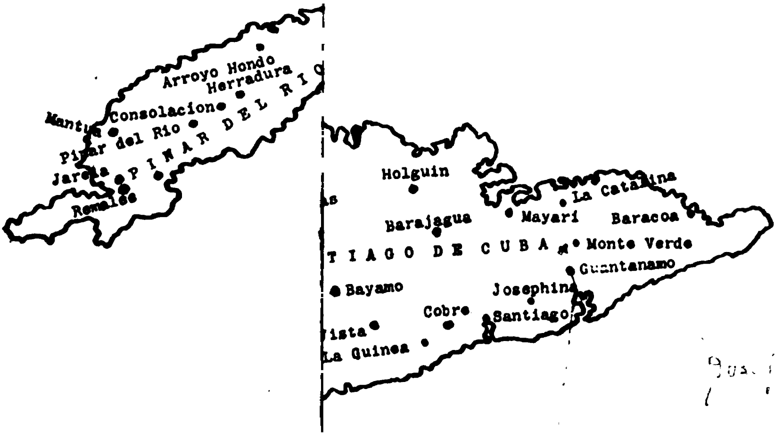
was also engaged part of the time in collecting shells and other things, especially after he met Gundlach. In Dr. Gray's *Letters* (2 : 555) these sentences explain the cause of the loss : "April 8th. It grieves my heart and will grieve yours badly when I tell you that your boxes were put under a cargo of wet sugar, which drained into them and have [*sic*] ruined the collection. . . . As to specimens to dispose of, say only one-half or one-third of the whole mass is left fit for it."



Josefina

[illegible] Santa Catalina de
[illegible] Saladero.

This list of Wright's stations has been submitted to Professor F. S. Earle, Director of the Estación Central Agronómica at Santiago de las Vegas, Cuba, whose familiarity with the country has enabled him to locate certain places and estates on the map of Cuba that would have been impossible to one less familiar with the geography of the region. In time, it may be possible to locate with accuracy the remaining stations, which are as yet unknown except from the brief and often unsatisfactory hints in Wright's correspondence. The notes added by Professor Earle to the account are marked with his initial — E.

Summary of Charles Wright's Correspondence with Asa Gray

I

1856.	25 N	Santiago.
	6 D	Cobre; written on third day of stay at that place.
	18 D	Filantropia (Mr. Bradford's estate) 12 miles from Cobre "among the mountains."
1857.	15 Ja	Filantropia.
	7 F	Filantropia. Mentions "two high points near here," viz., Nima-nima* and Loma del Gato.
	6 Mr	Filantropia. Speaks of going to Saltadero.
	9 Mr	Filantropia. Had finished packing; had visited 4 plantations.
	14 Mr	Cobre.
	3 Ap	Santa Catalina de Guaso or Saltadero (back of Guantanamo harbor). [Probably = Caimanera. — E.]
	5 Ap	Santa Catalina.
	23 Ap	Monte Verde.
	3 My	" "
	8 My	Saltadero. [Probably the same as Caimanera, the seaport of Guantanamo. — E.]
		[Here occurs a hiatus of four months in the correspondence.]
	9 S	At sea approaching New York.

II

1858.	30 N	Santiago de Cuba.
	5 D	Monte Verde. "Arrived here on 3d."
	17 D	" "
1859.	1 Ja	" "
	17 Ja	" "
	2 F	" "
	15 F	" "
	26 F	" "
	8 Mr	" "
	26 Mr	" "

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* See below, under Madelina.

	10 Ap	Monte Verde.
	24 Ap	" "
	14 My	Monte Verde. Had collected at La Perla, a neighboring plantation; also speaks of being "within two or three minutes' walk of the virgin forest in every direction."
	21 My	Monte Verde.
	1 Je	Santa Catalina de Guantanamo.
	9 Je	Monte Verde.
	21 Je	" "
	29 Je	" "
	5 Jl	" "
	12 Jl	" "
	16 Jl	" "
	5 Au	" "
	19 Au	" "
	31 Au	" "
	14 S	" "
	17 O	Santiago de Cuba. "Waiting for money" [apparently a chronic condition].
	6 N	Josephina, a hacienda or plantation belonging to the owner of La Perla, three leagues east from Nouvelle Sophie.
	17 N	Nouvelle Sophie. Mentions two excursions to the Farallones from base to summit. [Probably the high mountains east of Santiago. — E.]
	22 N	Nouvelle Sophie. Mentions having left Monte Verde about 17 September.
	26 N	Nouvelle Sophie. Says "protracted stay not advisable."
	9 D	La Madelina, "right at foot of Nima-nima." "Mr. Baitaill tells me that the crest which I have all along on Mr. Bradford's authority called Nima-nima, is La Guinea and that the former is away over towards the seashore."
	24 D	La Madelina. Mentions being at La Guinea 14th and 18th.
	26 D	" "
1860.	10 Ja	Santiago de Cuba. Speaks of going to-morrow to Guantanamo, then to Monte Verde and back by Nouvelle Sophie.
	14 Ja	Monte Verde. "Came from Guantanamo the 11th."
	18 Ja	Nouvelle Sophie.
	21 Ja	Santiago de Cuba.
	2 F	Filantropia.
	24 F	Nouvelle Sophie. "To-day I start for Monte Verde."
	26 F	Monte Verde. Speaks of plan for excursion to Mayari.
	15 Mr	Monte Verde. "I hope you wont let Eaton cut up these fern stems into cross sections. It seems to me simply ridiculous to attempt to exhibit the structure of a fern or palm by a cross section at any part, whereas a longitudinal section of either shows it perfectly, or the whole of it."
	23 Mr	Monte Verde.
	8 Ap	" "
	16 Ap	" "
	1 My	" "
	4 My	Monte Verde. "Monte Verde is nothing but a coffee estate."

[In suggesting labels Wright designates localities under judicial districts "which everybody knows" as follows:

Monte Verde = Yateras.
La Guinea = Ongolosongo [Hongolosonga. — E].
Filantropia = “
Nouvelle Sophie = Las Yaguas.
Josephina = Ramon].

17 My Monte Verde.
14 Jl “ “
1 Au Mayari. Mentions conditions of life at Cayo del Rey, where he spent some time.
18 Au Holguin. “Arrived this morning.”
(Wright apparently crossed the island directly north of Santiago and then along the north side of the island to Holguin).
22 Au Barajagua. “Left Holguin 19th and arrived here same day.”
25 Au Hato del Medio. [Four miles N. W. of Alto Cedro — E.]
9 S Nouvelle Sophie. “Arrived in Cuba (= Santiago de Cuba) the 6th.
13 S Saltadero.
15 S Monte Verde.
18 S Monte Verde. “Start to-morrow for Nouvelle Sophie, thence to Cuba and Bayamo and I may go from there to Holguin.”
19 S Saltadero.
20 S Saltadero. “Yesterday started for N. Sophie etc. expecting to get money in Saltadero or Cuba. To-day returned here in chase of that valueless certificate.”
17 N San Juan de Buenavista. “S. W. by S. 7 leagues from Bayamo.” [Probably S. E. instead of S. W., Buena Vista on new map is about 7 leagues S. E. of Bayamo.—E.]
26 N Bayamo. “Came this morning.” *
16 D Nouvelle Sophie. “On my way from Bayamo I turned aside and spent two weeks at Bradford's [Filantropia]. Found a few good things at La Guinea and Loma del Gato.”
1861. 4 Ja Monte Verde.
19 Ja “ “
27 Ja Nouvelle Sophie.
4 F Monte Verde.
2 Mr “ “
13 Mr Potosi (in Mt. Toro). “I am on an excursion through Monte Libano and Monte Toro.” [Probably north of Monte Verde.—E.]
25 Mr La Catalina near Sagua de Tanamo. “Tremendous farallones all around us not so easy to climb as you might imagine.”
5 My Monte Verde. “Hope to be off to-day or to-morrow for Baracoa.”
3 Je Baracoa. “I came from Mata [Probably S. W. of Baracoa; on new map, Mata Cafee.—E.] yesterday, a terribly boggy place and apparently filthy enough to kill mud-turtles. I stood it two weeks or more and I am in good health.” * * * “The streams are up preventing me going to the Yunque. † So soon as I can I shall pay it a visit,

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* Dr. Gray (Am. Jour. Sci. III, 31 : 12. 1886) says “his kind host, Dr. Don Manuel Yero, assisted him in making some profitable mountain excursions.” Judging from the above dates these must have been very brief.

† El Yunque—the anvil—is a flat-topped mountain six miles from Baracoa—one of the most conspicuous features of the sky line of eastern Cuba.

which will probably detain me but a few days. Then I shall return to Guantanamo stopping a day or two in the cuchillas (mountains)."

24 Je Monte Verde. "Got home yesterday tired out and my horse more so, seven days from Baracoa collecting a little by the way."

29 Jl Monte Verde. "After resting etc. I went on the road to Baracoa as far as the point where it turns northward to cross the mountains."

7 Au Monte Verde.

12 Au " "

4 S " "

5 O Valparaiso. "Just on the edge of Monte Libano." [Seven miles due west of Monte Verde.—E.]

17 O Monte Verde. "Got back yesterday."

24 O " "

24 N Nouvelle Sophie. "On the 20th I set out on my journey which if I am prospered will end at least for a time at "la Habana."

3 D Filantropia. Mentions a day on La Guinea. [Wright then went *via* Saltadero.]

13 D Mentions three excursions on La Guinea and Loma del Gato.

16 D Bayamo. The letter was mailed from Bayamo the 17th.

1862. 2 Ja Sancto Spiritos (Santo Espiritu).

4 Ja Sancto Spiritos "Shall remain a few days" * * * "There are as many as six or eight species of palms abundant along the route I have come, several of which I have not collected."

1 F Ingenio Fermina. "Fermina is a sugar estate two leagues from Bemba" [= Jovellanos.—E.] * * * "Left Santo Espiritu the 16th." [Here Wright found Gundlach, the zoologist, with whom he made many excursions.] In this letter Wright speaks of coming to an ingenio (sugar estate) the 24th where he stayed four or five days and "the next day here." Four leagues before reaching Villa Clara he mentions coming to a very hilly savanna.

23 Mr Mejia. "In my last [there is, however, no mention of this in any letter present in the collection] I told you I was going to the Cienaga de Zapata. I am domiciled about three leagues from it — have been to it twice." [Probably S. of Navajas. — E.]

28 Mr Mejia. "Returned from another excursion to the Cienaga."

[Here occurs a brief hiatus in the correspondence.]

17 Je San José [In Pinar del Rio, near Taco Taco or Santa Cruz. — E.]

[This place is mentioned in a previous letter as away S.W. of Habana.]

"I have been here more than three weeks with Don José Blain, who takes some interest in botany." . . . "I was there (Habana) the last days of May. It's a nasty place." . . . "I am about 20 leagues westward of Habana right at the foot (south side) of Rangel range of mountains or Los Organos."

23 Je "Returned from a visit of two or three days to Retiro, the other place Don José mentioned, when I was in Habana six days."

4 Au Santa Cruz. "Day before yesterday returned from an excursion of a few days south and west of here into the savannas, pinales and the famous 'vueltabago' — the tobacco district." [Properly vuelta abajo.]

13 Au San José.

8 S " "

28 S San José. "Three weeks ago went on an excursion northward and westward; we were gone two weeks."

13 O San José. "Gundlach will send my horses to Guanajay 15 leagues this side of Habana so probably I shall not go there now."

25 O Habana.

29 O San José. "To-day completes my fifty-first year."

27 N San José "Last month went from Guajaibon to Las Posas to Toscana a finca of Sauvalle (seaside) returning by San Marco and San Diego de Bañon. From there I turned S.W., and went to Herradura and Consolacion returning by Almacigos, Hato Queniando, Herradura, San Diego and so home."

10 D Ingenio Esperanza, "about a league from Pinar del Rio."

13 D Langvanillas. [This was probably the residence of an engineer of the above mentioned 'ingenio' about "four leagues away" where Wright mentioned having been invited to go in the last letter.]

1863. 9 Ja San José.

13 F " "

21 F " "

31 Mr " "

10 Ap " "

30 Ap Habana.

14 My — Wright had been at Fermina "for a few days to get plants Gundlach could not bring."

25 My Concordia. "Came here ten days since." Mentions going to the coast three leagues afoot. "Shall return in a few days to San José or rather Retiro whither friend Blain has now removed — a league."

15 Je Retiro. [This is the name of a finca near Taco Taco where Don José Blain lived. — E]

15 Jl Retiro.

27 Jl Toscano. [Probably the name of a finca near the N. coast, somewhat E. of Bahia Honda. — E]

5 S Retiro.

20 S "

20 D Los Remales. "The latter part of October I crossed the mountains to the north coast to Toscano, stayed there till Nov. 15. Went to Sagua (vega) climbed Guajaibon twice; made excursion to Cajalbarra (pine ridge crossing the island) followed down the north side near the coast through La Palma, Nombre di Dios, Bajas, Mantua. From Asiento viego (the Laguna) followed the same road to the Jarela, the terminus of my travels last year." He mentions wanting to go to the cape (Cape Corrientes?) "but as there was no guide I was content to go to a point on the south coast four leagues afoot."

1864. 15 Ja Retiro. "Three days ago I returned from my excursion of eighty," "Wrote 20th from Los Remales: a day or two later went to La Grife." [In this letter Wright mentions a serious experience with some poisonous plant which caused temporary loss of eyesight.]

5 F Retiro.

	14 F	Retiro
	7 Mr	"
	22 Ap	"
	30 Ap	Retiro. "On the 25th went to the coast at a point called Daranigan. [Point on the coast west from Retiro.—E]
	7 My	Retiro. "Yesterday went to the hills."
	19 My	Retiro. "Made an excursion of ten days eastward and southward to La Concordia, San Leon, etc."
	27 Jl	Habana. "Came here on the 21st."
	28 Jl	Habana. "Passport in pocket-book, plants boxed ready to embark,"
1865.	13 Ap	Weathersfield, Conn. "Shall start for Cuba before the end of the month."
	24 Ap	Weathersfield, Conn.

III.

	9 Je*	Cayo Bonito. "Down here on the edge of that grand swamp, the Cienaga de Zapata just south of Matanzas.
	18 Je	La Fermina; "returned yesterday."
	9 Jl	Matanzas.
	24 Jl	Janta. "Came here five or six days ago." . . . "Stayed some ten or twelve days at Palma Sola." [Probably near Matanzas or Jovellanos.—E.]
	15 Au	Matanzas.
	4 S	Habana.
	21 S	Balestina. [At this place the name is spelled Valestina.] † [Province of Pinar del Rio.—E.]
	23 O	"
	7 D	"
1866.	25 Ja	"
	13 F	"
	17 F	"
	15 Mr	Retiro.
	25 Mr	"
	3 Ap	Retiro.
	8 Ap	Toscano.
	14 Ap	"
	29 Ap	"
	2 Je	Retiro. "Left Toscano at 3 m. and arrived here about sunset."
	15 Je	Retiro. "Went to Rangel on the 8th" . . . "*He* went again to San Cristobal on the 10th."
	4 Jl	Retiro.
	23 Jl	"
	8 Au	"
	14 Au	Retiro. "Have been making short excursions of two or three days at a time into the palm and pine savannas near the coast."

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* Dr. Gray *loc. cit.* speaks of this third trip as commenced "in the autumn of 1865." In Gray's letter to Charles Wright (Letters, 2: 540) he mentions receiving a letter from Wright at Habana dated May 9th.

Gray *loc. cit.* says "Balestena" and speaks of it as "a cattle farm at the southern base of the mountains opposite Bahia Honda."

	20 Au	Retiro.
	26 S	"At a sawmill the last two weeks at Palacios" [near Pinar del Rio?].
	10 O	La Machina (this is the sawmill above mentioned).
	28 O	Habana.
	6 N	Retiro. "Spent some days in Concordia."
	2 D	"
	4 D	Retiro. "Yesterday went into the mountains" (La Palma Vega).
	12 D	La Machina. (Various additions to this letter were made from same place at various dates up to 20 D.)
	26 D	Arroyo Hondo. "To-morrow I go to Luis Lazo."
1867.	1 Ja	Guane. "From Arroyo Honda I went to Luis Lazo and staid a few days."
	6 Ja	La Grifa.
	10 Ja	Los Portales de Guane. "Yesterday I left La Grifa."
	21 Ja	Retiro.
	8 F	Habana.
	10 F	Habana. "Went to Matanzas yesterday for money."
	18 F	Habana. In this letter Wright recounts troubles he had to get a passport and other papers necessary to embark for Trinidad.
	19 F	Habana. "Everything arranged for my voyage" [to Trinidad]. [Apparently there is a hiatus in the correspondence here].
	20 Ap	Trinidad. "Since I last wrote you I went in the mountains to an old cafetal now a potrero or pasture. · · · "I came here about a week ago."
	24 Ap	Cuba (= Santiago de Cuba).
	26 Ap	Sta. Catalina de Guantanamo. "Arrived this morning." In this letter Wright mentions "letter of 8th" telling of loss of "great collections of the Vueltabago." *
	5 My	Monte Verde. "Back again."
	12 My	" †

The next letter is dated Cambridge, Mass., 23 Nov. 1868, in which Wright says "Done distributing." The sets of Cuban plants run thus: 2250, 2200, 2075, 1715, 1550, 1460, 1330, 1275, 1165, 960, 780, 750, 660, 620, 560.

The only breaks in the continuity of the above correspondence are as follows:

1. That from 8 May 1857 at Saltadero to 9 September 1857 written on the steamer approaching New York. This is the longest hiatus, and what may have been Wright's journeys during this period is largely a matter of conjecture. It seems probable that this time, like the rest of his first expedition, was spent on two or three of the plantations that formed the basis of his principal explorations in the province of Santiago.‡

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* *Cf.* foot-note p. 292.

† Dr. Gray (*loc. cit.*) says that Wright returned from his third visit in July 1867.

‡ Wright's single letter to Dr. Torrey during this period, preserved in the Torrey correspondence at the New York Botanical Garden, is dated 20 June 1857 from Monte Verde and bears out the above supposition.

2. That from 28 March 1862 written near the great swamp south of Matanzas (Cienaga de Zapata) to 17 June 1862 written from the province of Pinar del Rio, where he speaks of having been for "more than three weeks." There is still a hiatus of about two months concerning which we can only conjecture. It seems unlikely that this time was spent other than in the Matanzas province.

3. That from 19 February 1867 to 20 April 1867. At the former date Wright was at Habana making arrangements for a voyage to Trinidad on the south coast, and in the second he was engaged in collecting at Trinidad himself. It would seem that one intermediate letter at least was lost. It is hardly probable from our knowledge of Cuban steamship traffic (which in 1867 was surely not an improvement over the present conditions) that Wright stopped for any length of time at any intermediate station. It is highly probable that the greater part of this time was spent at Trinidad and vicinity covering a period of approximately two months. The amount of material collected at Trinidad may throw some light on this subject, when we know the stations corresponding to Wright's numbers. It is to be hoped that some one who has access to a collection made by Wright which possesses the original localities for the numbers will supplement this paper by further notes which will establish the type localities of Wright's species. Such an account would be a real contribution to our knowledge of the flora of Cuba.

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STIMULATION OF STERIGMATOCYSTIS BY CHLOROFORM

By MARION ELIZABETH LATHAM

NEW YORK
1905

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 32: 337-351. July, 1905]

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 32 : 337–351. 1905.]

Stimulation of Sterigmatocystis by chloroform

MARION ELIZABETH LATHAM

The response of fungi to the influence of salts and other chemical compounds, as manifested by accelerated growth, increased weight, and active evolution of carbon dioxide, has been the subject of several investigations within a recent period. Raulin's[*] early observations have been much extended by Richards[†] who has ascribed[‡] the action to a more economical use of the nutrition at hand, that is, he has proved the economic coefficient of Kunstmann[§] to decrease as the stimulant approaches its point of optimum efficacy. Ono,[||] Yashuda,[¶] Hattori,[**] Stevens,[††] Iwanoff,[‡‡] Benecke[§§] and others have extended the range of toxic compounds, all with concordant results; namely, that those substances which in larger amounts are fatal, serve to stimulate the organism to increase in activity when present in sufficiently small quantities, in accordance with the generalization of Hueppe.[*] In addition, Ono[†] has found that the waste through oxalic acid formation is at the same time lessened; and Watterson[‡] that although there is greater expiration of CO_2 the increase is only parallel with that of the crop and its production relatively normal. Schulz[§] working with yeast; Hueppe,[||] Effront,[¶] and Lindet[**] with bacteria; and Ono[††] and Livingston[‡‡] with algae have reached like conclusions as far as growth is concerned.

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[*] Raulin, J. Études chimiques sur la vegetation. Ann. Sc. Nat. Bot. V. **11** : 93. 1869.

[†] Richards, H. M. Die Beeinflussung des Wachsthums einiger Pilze durch chemische Reize. Jahrb. Wiss. Bot. **30** : 665. 1897.

[‡] Richards, H. M. The effect of chemical irritation on the economic coefficient of sugar. Bull. Torrey Club **26** : 463. 1899.

[§] Kunstmann, H. Ueber das Verhältniss z. Pilzernte u. verbrauchter Nährung. Inaug. Dissert. Leipzig, 1895.

[||] Ono, N. Ueber die Wachsthumsbeschleunigung einiger Algen u. Pilze. Jour. Coll. Sci. Imp. Univ. Tokyo **13** : 141. 1900.

[¶] Yashuda, A. On the effect of alkaloids upon some moulds. Bot. Mag. Tokyo **15**. 1901.

[**] Hattori, H. Studien über die Einwirkung der Kupfersulfats auf einige Pflanzen. Jour. Coll. Sci. Imp. Tokyo **15** : 371. 1901.

[††] Stevens, F. L. The effect of aqueous solutions upon the germination of fungus spores. Bot. Gaz. **26** : 377. 1898.

[‡‡] Iwanoff, K. S. Ueber die Wirkung einiger Metallsalze und einatomiger Alkohole auf die Entwickelung von Schimmelpilzen. Bot. Centralb. **98** : 97. 1905.

[§§] Benecke, W. Die zur Ernährung der Schimmelpilze nothwendigen Metalle. Jahrb. Wiss. Bot. **28** : 487. 1895; and Einige neuere Untersuchungen über den Einfluss von Mineralsalzen auf Organismen. Bot. Zeit. **62**^{2} : 113. 1904.

Copeland and Kahlenberg,[||||] and Kahlenberg and True,[***] and more lately Kanda,[†††] working with higher plants tell of stimulation caused by salts. Similarly Copeland[‡‡‡] has obtained increased CO_2 evolution from work with phanerogams and tadpoles, interpretating the apparent vigor, however, as an evidence of harm rather than benefit.

Townsend[§§§] mixed ether with water supplied to seeds and thus hastened germination. He has also shown that seeds, subjected to HCN gas[||||||] for a short time, sprout sooner and grow more rapidly than those not so treated; that *Avena* seedlings grown in a sufficiently weak atmosphere of ether are at first retarded and then accelerated, finally returning to their normal rate of growth if the shock be not too long continued; and that in small amounts ether vapor will aid germination in the spores of *Penicillium* and *Mucor*,* although larger doses are inimical. Duggar † says that a saturated atmosphere of chloroform is fatal to the spores of *Aspergillus flavus* and *Phycomyces* and without benefit to *Sterigmatocystis*, and that ether is of no consequence as a stimulant in germinating *Aspergillus*. With *Aspergillus* (*Sterigmatocystis*) *niger*, Kosinski ‡ finds respiration retarded when exposed to ether fumes.

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[*] Hueppe, F. The Principles of Bacteriology, 89, 90. Trans. by E. O. Jordan.

[†] *L. c.*

[‡] Watterson, A. The effect of chemical irritation on the respiration of fungi. Bull. Torrey Club 31 : 291. 1904.

[§] Schulz. Ueber Hefegifte. Bot. Zeit. 46 : 610. 1888.

[||] *L. c.*

[¶] Effront. Compt. rend. 119 : 169. 1894.

[**] Lindet. Compt. rend. 138 : 508. 1904.

[††] *L. c.*

[‡‡] Livingston, B. E. Chemical stimulation of a green alga. Bull. Torrey Club 32 : 1. 1905.

[||||] Copeland, E. B. & Kahlenberg, L. The influence of the presence of pure metals upon plants. Trans. Wis. Acad. 12 : 454. 1899.

[***] Kahlenberg, L. & True, R. H. On the toxic action of dissolved salts. Bot. Gaz. 22 : 81. 1896.

[†††] Kanda, M. Reizwirkung einiger Metallsalze auf das Wachsthum höherere Pflanzen. Jour. Coll. Sci. Imp. Tokyo 19 : 1. 1904.

[‡‡‡] Copeland, E. B. Chemical stimulation and the evolution of CO_2. Bot. Gaz. 35 : 81. 1903.

[§§§] Townsend, C. O. The effect of hydrocyanic acid gas upon grains and other seeds. Bot. Gaz. 31 : 241. 1901.

[||||||] Townsend, C. O. The correlation of growth under the influence of injuries. Ann. Bot. 11 : 509. 1897.

Ewart,§ working with chloroform in the water of water plants noted suspension of CO_2 assimilation agreeing with the earlier results of Claude Bernard. Kegel,|| however, finds with *Elodea canadensis* an increment of CO_2 assimilation in some percentages of ether and chloroform, but a sudden check in the case of a lesser amount. On the other hand, Bonnier and Mangin ¶ were able, by adding ether carefully, to stop assimilation of CO_2 without affecting respiration, an observation in accordance with that of Schwarz,** who, with both ether and chloroform, has recorded stoppage of oxygen evolution not accompanied by elimination of CO_2 evolution until the plant was fatally affected. Ewart's †† results with mosses were similar. Movement in the protoplasm of *Philotria* (*Elodea*),

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* Townsend, C. O. Effect of ether upon the germination of seeds and spores. Bot. Gaz. 27: 458. 1899.

† Duggar, B. M. Physiological studies with reference to the germination of certain fungous spores. Bot. Gaz. 31: 38. 1901.

‡ Kosinski, I. Die Athmung bei Hungerzuständen u. unter Einwirkung von mechanischen u. chemischen Reizmitteln bei Aspergillus niger. Jahrb. Wiss. Bot. 37: 137. 1902.

§ Ewart, A. J. Action of chloroform on CO_2 assimilation. Ann. Bot. 12: 415. 1898.

|| Kegel, W. Ueber den Einfluss von Chloroform und Aether auf die Assimilation von Elodea canadensis. Inaug. Dissert. Göttingen, 1905.

¶ Bonnier, G. & Mangin, L. Recherches sur l' action chlorophyllienne séparée de la respiration. Ann. Sci. Nat. VII. 3: 5. 1886.

** Schwarz, F. Zur Kritik der Methode des Gasblasenzählens an submersen Wasserpflanzen. Untersuch. Bot. Inst. zu Tübingen, 1: 97. 1881.

†† Ewart, A. J. On assimilatory inhibition in chlorophyllous plants. Jour. Linn. Soc. 31: 364. 1896.

as seen by Farmer and Waller,* ceased under the influence of ether and chloroform, the latter proving more powerful.

With various seedlings in an ether atmosphere, Morkowine † obtained increase of respiration in the light; Bonnier and Mangin ‡ got no such effect in the dark. Puriewitsch, as quoted by Morkowine, § concluded that in ether vapor, transformation of sugar to starch is inhibited. Jumelle || believes transpiration increased in light and decreased in dark by ether, Zaleski ¶ that proteid formation is hindered by the same substance. Pfeffer ** cites Elfving †† and Laurén ‡‡ as authorities for the observation that CO_2 formation, but not growth, is augmented in higher plants by a not too long exposure to chloroform; and finally, Johanssen §§ has proved the economic value of ether in forcing early blooming in flowering plants. The period of winter rest is shortened, rapidity of growth and total evolution of CO_2 increased.

The majority of the investigations with chloroform and ether, it will be noted, have had to do with their effect on green plants. Townsend |||| and Duggar ¶¶ to be sure, experimented with fungus spores but their work stopped with germination; and Kosinski *** was concerned only with the respiration factor. It has been the aim of the piece of work here described to compare the effect of chloroform vapor on fungus growth, as shown by increase in dry substance, with the results quoted above. Therefore *Sterigmatocystis nigra* (*Aspergillus niger*) in the main and *Penicillium glaucum*

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* Farmer, J. B. & Waller, A. D. Observations on the action of anaesthetics on vegetable and animal protoplasm. Proc. Royal Soc. 63: 213. 1898.

† Morkowine, N. Recherches sur l' influence des anesthésiques sur la respiration des plantes. Rev. Gen. de Bot. 11: 289. 1899.

‡ Bonnier & Mangin, *l. c.*

§ *L. c.*

|| Jumelle, H. Influence des anesthésiques sur la transpiration des végétaux. Rev. Gen. de Bot. 2: 417. 1890.

¶ Zaleski, W. Zur Aetherwirkung auf die Stoffumwandlung in den Pflanzen. Ber. Deuts. Bot. Gesells. 18: 292. 1900.

** Pfeffer. Physiology of Plants, 1: 564. Trans. by Ewart.

†† Elfving. Ueber die Einwirkung von Aether u. Chloroform auf die Pflanzen. Oefversigt af Finska Vetensk. Soc. Forh. 28: 36. 1886.

‡‡ Laurén. Bot. Jahresb. 20^1: 92. 1892.

§§ Johanssen, W. L. Das Aether-Verfahren beim Frühtreiben. Jena. 1900.

|||| Bot. Gaz. *l. c.*

¶¶ *L. c.*

*** *L. c.*

to a lesser extent were grown on the nutrient solutions prescribed by Pfeffer * and designated as A and C in the first paper on the subject by Richards,† the cultures confined in an atmosphere of chloroform of known or approximately known value and the effect upon dry weight of the crop, economic coefficient and acid coefficient noted.

The work was done in the botanical laboratory of Barnard College during the years 1904 and 1905 under the guidance of Dr. Herbert Maule Richards, to whom his student is much indebted for his kindness and interest. To the New York Botanical Garden many thanks are due for extending the privileges of the library.

To grow the fungi, small dishes 70 mm. in diameter and 30 mm. deep were used. These, in all series following IV, were of the non-sol glass of Whitall, Tatum & Co. Each culture dish rested on two strips of glass over a half Petri dish containing 40 c.c. of a 10 per cent. KOH solution. The Petri dish in turn sat upon a ground-glass plate. On glass strips laid across the culture dish was supported a small watch glass to receive the chloroform. In operating, each dish was arranged as described and all covered by a bell-jar which was ground down on to the glass plate in a glycerine-gelatine seal. After the seal had hardened, amounts of chloroform calculated to the capacity of the jars — due allowance having been made for the solids and liquids within — were run in through the neck which was at once closed with a rubber stopper. It is possible in this way to regulate the supply of chloroform vapor with tolerable accuracy, for the placing of the stopper in position occupies but a moment and relatively little of the chloroform can volatilize and escape. Moreover, the seal at the base of the jar is sufficiently strong to be proof against any small pressure generated by the vaporizing liquid.

In manipulation, the usual precautions were observed. The culture dishes, before each using, were soaked in dichromate cleaning solution, washed, rinsed in distilled and redistilled water and sterilized in hot air at 100°–120° C. The bell-jars were

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* Pfeffer, W. Ueber Election organischer Nährstoffe. Jahrb. Wiss. Bot. **28**: 205. 1895.

† *L. c.*

rinsed in formalin; the glass strips and watch glasses were washed and sterilized in hot air (100°–120° C.). All flasks and pipettes were handled similarly.

The redistilled water mentioned above was the distilled water furnished for ordinary laboratory purposes in the college — the still is tin-lined — redistilled and condensed through a block-tin tube. A considerable portion passing over at first was discarded and the operation stopped while a quantity remained in the distilling flask. This water was used in making all solutions, as well as for the final rinsings of the apparatus. Its specific conductivity as determined in the physics laboratory varied between 2.74×10^{-6} and 1.59×10^{-6}. The salts used were the best quality supplied by Merck & Co. White rock-candy furnished the sugar. A solution of 30–50 per cent. was made, filtered through glass wool to remove the bits of string and kept tightly corked for use. The proper amount from the stock was taken for each solution made for a series. Iron, also, was kept in solution, but the other salts were weighed out as required. The formulae of the solutions are as follows:

A		C	
NH_4NO_3	1.00 gm.	Asparagine	0.50 gm.
K_2HPO_4	0.50 gm.	KH_2PO_4	0.50 gm.
$MgSO_4$	0.25 gm.	$MgSO_4$	0.25 gm.
$FeSO_4$	trace.	$FeSO_4$	trace.
Sugar	5.00 gm.	Sugar	5.00 gm.
Water	100.00 c.c.	Water	100.00 c.c.

The chloroform was the best grade made by Merck, known to contain .02 per cent. of absolute alcohol to prevent decomposition, which, however, in the quantities of the anaesthetic used is negligible. Repeated tests with $AgNO_3$ showed that no free Cl was present.

Sowing the fungus was accomplished by dipping the end of a clean glass rod into the nutrient solution, rubbing it over the dry spores, redipping it into the fluid, and agitating well to secure uniform distribution. The smooth white felts of the control cultures testified to the effectiveness of the treatment and the purity of the reagents. In practice, enough nutrient solution was made at a time for one complete series — the iron alone omitted. This solution was boiled, cooled and 50 c.c. taken in an accurate pipette to be analyzed for acid and sugar. The remainder was then inoculated in bulk with spores in the method described and doses of 50 c.c. run from the pipette into each culture dish. Last of all the iron, a mere trace, was added.

The crop was reaped when the controls showed a full fruited surface. The felts were thrown on weighed filters, washed thoroughly with boiling water, dried in hot air at 70°–80° C., cooled in a desiccator and the dry weight ascertained. The filtrate made up to 250 c.c. was analyzed, as recorded, for oxalic acid, or sugar, or both. Determinations for oxalic acid in the filtrate from the *Sterigmatocystis* * were made at once. Ten cubic centimeters of the solution were titrated against standardized NaOH. The total acidity, less the acidity at the time of setting up (that of the stock solution), gave the correct amount of acid produced during growth.

A measured quantity of the filtrate, generally 100 c.c., was next inverted by boiling with 0.5 c.c. of 5N HCl and the invert sugar estimated by the Fehling test. When asparagine was present, extra care was taken. A cubic centimeter or 1.5 c.c. of acid was used for inversion and the time of boiling extended, water being added if necessary. Asparagine, by virtue of its amide groups, will reduce a copper solution and invalidate a test for sugar in its presence. Hard boiling with HCl serves to destroy the molecule with the production of NH_4Cl, which does not interfere with the analysis. The Fehling solution was kept in two portions. The stock $CuSO_4$ contained 69.28 gms. per liter; the alkaline tartrate, 100 gms. of NaOH and 350 gms. of $KNaC_4H_4O_6$ per liter. Standardization was made against accurately freshly prepared 1 per cent. dextrose. For each analysis 5 c.c. of each stock solution and 40 c.c. of H_2O were used. Calculations were made on the basis that under such conditions 0.5 gm. of invert sugar reduces 97 c.c. of the Fehling solution.†

The fruiting of the control cultures, as mentioned, determined the reaping of the crop. The period of growth varied with the temperature. Near its optimum of 34° C., *Sterigmatocystis* was ready to harvest in seven to ten days when grown on solution A, or in four to five days when asparagine replaced the NH_4NO_3; while the period of cultivation extended over two to three weeks if the temperature fell to 20°–25° C. The lack of constant conditions is to be regretted, especially in view of indications which may be discussed later.

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* Wehmer. Entstehung und physiologische Bedeutung der Oxalsäure im Stoffwechsel einiger Pilze. Bot. Zeit. 49: 1891.

† Sutton. Volumetric Analysis. Ed. 1904.

The first effect of $CHCl_3$ used in such an amount as is necessary to cause noticeable stimulation is to retard the germination of the spores. With the smallest quantities employed, the first hyphae did not appear until six to twenty-four hours after growth had started in the chloroform-free air. The second effect seen is the production of toughened, buckled felts by a rapid growth accompanied by repression of conidial fructification, as observed also when the organism is stimulated by salts, etc. At harvesting, felts grown under optimum stimulation gave on an average crops 200 per cent. to 300 per cent. as heavy as the normal, rising in some instances to 500 per cent. and 700 per cent. The curve representing the influence of $CHCl_3$ on growth is similar to those of other stimulants; it rises in a characteristic manner to a maximum and then falls again.

Sterigmatocystis cultivated on solution A at a temperature varying between 20° and 30° C. grows more luxuriantly when the content of the atmosphere is, per liter, the vapor of $\frac{1}{8}$ c.c. of liquid $CHCl_3$ and the beneficial effect increases until $\frac{1}{2}$–$\frac{7}{12}$ c.c. per liter are used, when decrease begins. If the bell-jar contains per liter over 1 c.c. of $CHCl_3$ (vaporized), germination is permanently stopped, although the spores will grow readily if placed in air. When asparagine, instead of NH_4NO_3, is the source of nitrogen (solution C) the sensitivity of the *Sterigmatocystis* is increased. Optimum growth then takes place when $\frac{1}{6}$–$\frac{1}{4}$ c.c. of $CHCl_3$ is present per liter, and $\frac{2}{3}$ c.c. is sufficient to arrest development.

The augmentation in weight is accompanied by a relatively lessened acid formation and sugar consumption; that is to say, the ratio of the acid to the crop, and of the sugar used to the crop is lowered. For example, in Series X, Table I, the acid coefficient is lowered from 2.3186 to .4160 grams per gram fungus when the atmosphere held $\frac{1}{2}$ c.c. of $CHCl_3$ vaporized and to .3551 grams per gram fungus when the content was $\frac{7}{12}$ c.c.; at the same time, the economic coefficient fell from 11.493 to 3.214 and 3.201 grams per gram fungus respectively. The average figures for the atmospheres quoted are for acid coefficient 0.6932 and 0.5696 and for sugar 3.744 and 3.514 against 1.4123 and 5.358 for the normal culture. The economic coefficient of the controls varies considerably from that found by Kunstmann * and Richards,† to be sure, but the figures obtained are fairly stable. The same thing is true of the data for oxalic acid as compared with those of Ono.‡ That irregular fluctuations may be regarded as due to individual peculiarities is indicated by the consistency in the various factors. For instance, a lack of due increase in weight is, in general, accompanied by an abnormal rise in the coefficients of acid and sugar, pointing to internal differences rather than to errors in calculation or manipulation.

Chloroform belongs to the so-called catalytics in Loew's § classification. The small amount absorbed by the water of the nutrient solution affects the protoplasm so as to cause it to work more economically, possibly through action on the enzyme formed.|| However that may be, the figures point again to the explanation of the phenomena advanced by Richards¶ and by Ono** as his third alternative, *i. e.*, that the fungus can under the conditions produced by the stimulant thrive more economically.

The sensitivity of *Penicillium* on solution A is about equal to that of *Sterigmatocystis* on solution C.

Another question of interest is the stage in the growth at which the $CHCl_3$ is most potent. To learn this, series were run with the optimum of $CHCl_3$ placed in some when set up as before and in others after the spores had been allowed to start. The former were more prosperous (Table III); that is, the impulse given at germination is more effective than one applied later, but even after complete germination, the fungus responds, although in a lesser degree, in the characteristic fashion.

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* *L. c.*

† *L. c.*

‡ *L. c.*

§ Loew. "Naturliche System der Gift Wirkungen." Munich, 1893, as quoted by Davenport, Experimental Morphology, p. 7.

|| Hueppe (*l. c.*) suggests this vaguely.

¶ *L. c.*

** *L. c.*

That chloroform cannot furnish carbon was settled by sowing spores on a solution of the necessary salts, but omitting sugar, and then placing in optimum chloroform conditions. Not a sign of a germ tube appeared even after two weeks' time.

Although there are no direct data on this point at present, still it is very evident to the worker that a given amount of chloroform is more efficacious at a higher than at a lower temperature, that the optimum point recedes as the temperature rises. It was impossible to keep the temperature of the room in which the cultures were grown constant for any considerable period, but the truth of the statement was many times manifest at various stages in the development. In one or two instances when the crop ripened at from 32–34° C., the optimum was pushed back from $\frac{1}{2}$–$\frac{7}{12}$ to $\frac{5}{12}$ or even $\frac{1}{3}$ c.c. per litre.

The facts indicated are, that:

1. When present in small quantities $CHCl_3$ vapor acts as a characteristic stimulant to the growth of *Sterigmatocystis nigra* and *Penicillium glaucum*.

2. Larger quantities are inimical or fatal.

3. Increased growth is attended by relatively less acid formation and less sugar consumption indicating greater economy in metabolism.

4. The time of greatest sensitiveness is at the germination of the spores.

5. $CHCl_3$ acts as a stimulant purely since it cannot be a source of carbon.

6. The effect of a given amount of the anaesthetic is greater as the temperature rises.

Barnard College, Columbia University,
April, 1905.

TABLE I.

Sterigmatocystis nigra.—SOLUTION A.

	CHCl$_3$ per li.	Net Weight.	Per Cent. Increase Over Normal.	Oxalic Acid by Weight	Oxalic Acid per gm Fungus.	Sugar Used.	Economic Coefficient.	
							Sugar: Fungus.	Fungus: Sugar.
	c.c.	grams.		grams.	grams.	grams.		
Series I.	0	.5836	—	.3942	.6754	2.7069	4.6378	.2156
Time 14 days.	0	.6628	—	.4097	.6181	3.0790	4.6454	.2152
Temp. 26°–33°C.	$\frac{1}{3}$	.7400	18.74	.2164	.2924	2.1130	2.8554	.3502
10% sugar sol.	$\frac{5}{12}$	.7360	18.10	.1597	.2170	2.2754	2.9820	.3353
	$\frac{1}{2}$	.6838	9.72	.2860	.4182	1.9804	2.8960	.3453
	$\frac{7}{12}$	.7088	13.73	.1468	.2071	1.9885	2.8054	.3564
Series II.	0	.1850	—	.1933	1.044	.7926	4.284	.2334
Time 12 days.	0	.2128	—	.1571	.7382	.8888	4.176	.2394
Temp. 24°–27°C.	$\frac{5}{12}$	.2950	48.31	.3622	1.227	1.3099	4.437	.2254
	$\frac{1}{2}$	.3314	66.62	.2566	.7743	1.5031	5.435	.2204
	$\frac{7}{12}$	.4216	111.9	.2203	.5225	1.6829	3.991	.2505
	$\frac{2}{3}$	.3110	56.36	.1764	.5672	1.3443	4.321	.2314
Series III.	0	.1806	—	.1996	1.105	.7502	4.164	.2407
Time 12 days.	0	.1294	—	.1585	1.224	.5492	4.487	.2228
Temp. 24°–27°C.	$\frac{5}{12}$	.5036	224.9	.1558	.3093	1.5577	3.091	.3309
	$\frac{1}{2}$	.4530	192.2	.1276	.2816	1.3916	3.072	.3255
	$\frac{7}{12}$	.2448	57.93	.0866	.3537	.6952	2.839	.3521
	$\frac{2}{3}$	.1598	3.10	.0618	.3867	.4482	2.804	.4488
Series IV.	0	.1750	—	.1392	.7954	.639	3.651	.2738
Time 12 days.	0	.0790	—	.0928	1.174	.281	3.557	.2811
Temp. 22°–28°C.	$\frac{1}{3}$	.2620	106.3	.1624	.6198	1.084	4.137	.2147
	$\frac{5}{12}$	.2710	113.4	.1753	.6468	1.080	3.985	.2509
	$\frac{1}{2}$	.2100	65.4	.1469	.6995	.833	3.966	.2521
	$\frac{7}{12}$	.2780	118.9	.1469	.5284	1.178	4.237	.2359
	$\frac{2}{3}$	.2226	75.3	.1005	.4535	1.062	4.770	.2096
	$\frac{3}{4}$	.1690	33.1	.1237	.7319	.813	4.810	.2078
Series V.	0	.0920	—	.1391	1.512	.462	5.021	.1991
Time 9 days.	0	.0640	—	.1121	1.751	.353	5.515	.1813
Temp. 26°–31°C.	$\frac{1}{3}$	.1170	50.0	.2589	2.212	.595	5.085	.1966
	$\frac{5}{12}$	.1550	98.7	.2705	1.745	.747	4.819	.2075
	$\frac{1}{2}$	.1370	75.6	.2628	1.918	.704	5.138	.1946
	$\frac{7}{12}$	.1590	103.8	.2551	1.604	.767	4.824	.2073
	$\frac{2}{3}$	.1110	44.3	.2164	1.949	.630	5.676	.1761
	$\frac{3}{4}$	.1750	124.3	.2056	1.174	.837	4.783	.2090
Series VI.	0	.0564	—	.0773	1.371	0.181	3.195	.3130
Time 7 days.	0	.0360	—	.0619	1.719	0.141	3.917	.2553
Temp. 27°–34°C.	$\frac{1}{3}$	.3650	690.0	.2783	0.762	1.480	4.055	.2466
	$\frac{5}{12}$	.2020	337.2	.1739	0.861	0.750	3.713	.2693
	$\frac{1}{2}$	.2720	488.7	.1662	0.611	0.623	2.290	.4366
	$\frac{7}{12}$	.2736	492.2	.1971	0.724	0.976	3.567	.2803
	$\frac{2}{3}$	.2256	388.3	.1469	0.651	0.623	2.761	.3621
	$\frac{3}{4}$	.2246	386.1	.1469	0.654	0.701	3.121	.3204

TABLE I.—*Concluded.*

Sterigmatocystis nigra.—SOLUTION A.

	$CHCl_3$. per li.	Net Weight.	Per Cent. Increase Over Normal.	Oxalic Acid by Weight.	Oxalic Acid per gm. Fungus	Sugar Used.	Economic Coefficient.	
							Sugar: Fungus.	Fungus: Sugar.
	c.c.	grams.		grams.	grams.	grams.		
Series VII.	0	.0200	—	.0541	2.705	.253	12.64	.0791
Time 10 days.	0	.0280	—	.0541	1.932	.290	10.35	.0967
Temp. 24°–30°C.	$\frac{1}{3}$	.1290	437.5	.1852	1.436	.574	4.453	.2246
	$\frac{5}{12}$	.1340	458.3	.0696	0.5194	.518	3.865	.2587
	$\frac{1}{2}$	.1952	713.3	.0812	0.4160	.627	3.214	.3111
	$\frac{7}{12}$	.1960	716.7	.0696	0.3551	.627	3.201	.3124
	$\frac{2}{3}$	.1854	672.5	.0696	0.3754	.653	3.520	.2841
	$\frac{3}{4}$	.1420	491.7	.0501	0.3528	.326	2.296	.4356
Series VIII.	0	.0570	—	.1314	2.305	.343	6.025	.1659
Time 13 days.	0	.0660	—	.1275	1.932	.361	5.462	.1830
Temp. 24°–30°C.	$\frac{1}{3}$	.0980	59.4	.1469	1.499	.488	4.984	.2006
	$\frac{5}{12}$	.1990	223.6	.0696	0.3497	.574	2.885	.3387
	$\frac{1}{2}$	.1810	194.3	.0773	0.4271	.713	3.940	.2538
	$\frac{7}{12}$	.2650	330.9	.0696	0.2626	.701	2.647	.3778
	$\frac{2}{3}$	.1880	205.7	.0503	0.2676	.427	2.287	.4408
	$\frac{3}{4}$	.1130	83.7	.0194	0.1717	.253	2.237	.4470
Series IX.	0	.0820	—					
Time 21 days.	0	.0987	—					
Temp. 23°–25°C.	$\frac{1}{3}$	.1810	101.3					
	$\frac{5}{12}$	.1930	114.7					
	$\frac{1}{2}$	.2508	178.9					
	$\frac{7}{12}$	.1510	68.0					
	$\frac{2}{3}$	.3594	299.8					
	$\frac{3}{4}$	.2390	165.9					

TABLE II.

AVERAGES OF DATA GIVEN IN TABLE I.

$CHCl_3$ per li.	Net Weight.	Per Cent. Increase Over Normal.	Oxalic Acid by Weight.	Oxalic Acid per gm. Fungus.	Sugar Used.	Economic Coefficient.	
						Sugar: Fungus.	Fungus: Sugar.
c.c.	grams.		grams.	grams.	grams.		
0	[illegible]	—	0.1563	1.4123	0.754	5.3579	0.2122
$\frac{1}{3}$	0.2702	209.0	0.2080	1.1368	1.056	4.2615	0.2388
$\frac{5}{12}$	0.2987	181.9	0.1796	0.7344	1.101	3.722	0.2771
$\frac{1}{2}$	0.3015	220.5	0.1756	0.6932	1.047	3.744	0.2924
$\frac{7}{12}$	0.2998	223.7	0.1490	0.5696	1.077	3.514	0.2966
$\frac{2}{3}$	0.2518	249.3	0.1174	0.6643	0.741	3.734	0.3076
$\frac{3}{4}$	0.1771	214.1	0.1091	0.6168	0.586	3.449	0.3239

TABLE III.

Sterigmatocystis nigra.—SOLUTION C.

	$CHCl_3$ per li.	Net Weight.	Sugar Used.	Economic Coefficient.	
				Sugar: Fungus.	Fungus: Sugar
	c.c.	grams.	grams.		
Series X.	0	0.0596	1.167	19.58	0.0511
Time 7 days.	0	0.0340	1.167	34.32	0.0291
Temp. 25°-32° C.	$\frac{1}{12}$	0.0210	0.858	40.86	0.0245
	$\frac{1}{6}$	0 0290	0.858	29.59	0.0339
	$\frac{1}{4}$	0.1150	1.038	9.026	0.1108
	$\frac{1}{3}$	0.0720	0.930	12.91	0.0774
	$\frac{5}{12}$	0.0650	0.832	12.80	0.0781
	$\frac{1}{2}$	0.1120	0.930	8.303	0.1204
Series XI.	0	0.0886			
Time 7 days.	$\frac{1}{3}$	0.3106			
Temp. 30°-31° C.	$\frac{5}{12}$	0.3610			
	$\frac{1}{2}$	0.2340			
Series XII.	0	0.1910			
Time 4 days.	0	0.1660			
Temp. 32°-34° C.	$\frac{1}{6}$	0.2810			
	$\frac{1}{4}$	0.2860			
	$\frac{1}{3}$	0.1920			
Series XIII.	0	0.4470			
Time 4 days.	0	0.3520			
Temp. 27°-32° C.	$\frac{1}{12}$	0.2200			
	$\frac{1}{6}$	0.4660			
	$\frac{1}{4}$	0.5790			
	$\frac{1}{3}$	0.2130			
	$\frac{5}{12}$	0.2120			
	$\frac{1}{2}$	0.1980			

TABLE IV

Sterigmatocystis nigra.—SOLUTION A

	$CHCl_3$ per li.	Net Weight.	Oxalic Acid by Weight.	Oxalic Acid per Gm. Fungus.	Sugar Used.	Economic Coefficient.	
						Sugar: Fungus.	Fungus: Sugar.
	c.c.	grams.	grams.	grams.	grams.		
Series XIV. Temp. 24°–31° C. $CHCl_3$ in before germination, out after germination, *i. e.*, in 7 days. Total time 9 days.	0	0.1470	0.1276	0.8680	0.477	3.245	0.3082
	0	0.0950	0.1044	1.099	0.274	2.884	0.3467
	½	0.3200	0.1121	0.3503	0.899	2.809	0.3559
	7/12	0.1500	0.0348	0.2320	0.365	3.063	0.4110
$CHCl_3$ after germination, *i. e.*, after 2 days; $CHCl_3$ in 10 days. Total time 12 days.	0	0.0840	0.1585	1.887	0.441	5.250	0.1905
	0	0.0794	0.1778	2.239	0.365	4.597	0.2175
	½	0.1240	0.0309	0.2492	0.404	3.258	0.3069
	7/12	0.2530	0.0619	0.2447	0.640	2.530	0.3953
Series XV. Temp 27°–32° C. $CHCl_3$ in before germination, out after germination, *i. e.*, in 3 days. Total time 7 days.	0	0.2200	0.1925	0.8750	0.957	4.350	0.2299
	0	0.1336	0.2040	1.527	0.777	5.816	0.1719
	½	0.2760	0.1584	0.5739	1.015	3.677	0.2719
	7/12	0.3040	0.1198	0.3941	0.996	3.431	0.2915
$CHCl_3$ in after germination, *i. e.*, after 2 days; $CHCl_3$ in 8 days. Total time 10 days.	0	0.1780	0.2744	1.542	0.936	5.258	0.1902
	0	0.1350	0.2435	1.804	0.751	5.563	0.1798
	½	0.0490	0.0154	0.3143	0.257	5.245	0.1907
	7/12	0.0280	0.0193	0.6893	0.257	9.178	0.1089
Series XVI. Temp. 23°–29° C. $CHCl_3$ in before germination, in 4 days. Total time 14 days.	0	0.0780					
	½	0.3730					
	7/12	0.1700					
$CHCl_3$ in after germination. In 14 days. Total time 16 days.	0	0.1190					
	½	0.2000					
	7/12	0.2676					
Series XVII. Temp. 26°–28° C. $CHCl_3$ in before germination. In 4 days. Total time 8 days.	0	0.0674					
	½	0.1470					
	7/12	0.1530					
$CHCl_3$ in after germination. In 12 days. Total time 12 days.	0	0.1040					
	½	0.0330					
	7/12	0.1040					

TABLE V

Penicillium glaucum.—SOLUTION A

	$CHCl_3$ per li.	Net Weight.	Sugar Used.	Economic Coefficient.	
				Sugar: Fungus.	Fungus: Sugar.
	c.c.	grams.	grams.		
Series XVIII.	0	0.0330	0.288	8.727	0.1145
Time 17 days.	0	0.0620	0.397	6.403	0.1561
Temp. 18°–26° C.	$\frac{1}{2}$	0.1320	0.726	5.500	0.1818
	$\frac{1}{6}$	0.1124	0.532	4.733	0.2112
	$\frac{1}{4}$	0.1054			
	$\frac{1}{3}$	0.0950	0.523	5.505	0.1816
	$\frac{5}{12}$	0.0540	0.302	5.592	0.1788
	$\frac{1}{2}$	0.0416	0.257	6.178	0.1618
Series XIX.	0	0.0664			
Time 14 days.	0	0.0930			
Temp. 19°–24° C.	$\frac{1}{12}$	0.0700			
	$\frac{1}{6}$	0.1580			
	$\frac{1}{4}$	0.2980			
	$\frac{1}{3}$	0.0400			
	$\frac{5}{12}$	0.0760			
	$\frac{1}{2}$	0.0400			
Series XX.	0	0.0490			
Time 19 days.	0	0.0534			
Temp. 21°–26° C.	$\frac{1}{12}$	0.0720			
	$\frac{1}{6}$	0.0950			
	$\frac{1}{4}$	0.0580			
	$\frac{1}{3}$	0.0268			
	$\frac{5}{12}$	0.0570			
	$\frac{1}{2}$	0.0300			

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Lists of titles of Contributions may be had on application.

LUCIEN M. UNDERWOOD,
Professor of Botany.

COLUMBIA UNIVERSITY,
NEW YORK CITY.

RECEIVED,
OCT 23 1906

CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 219

PHYTOGEOGRAPHICAL EXPLORATIONS IN THE COASTAL PLAIN OF GEORGIA IN 1904

By ROLAND M. HARPER

NEW YORK

1905

[From the Bulletin of the Torrey Botanical Club 32: 451-467. 1905].

from LIBRARY OF THE GRAY HERBARIUM
HARVARD UNIVERSITY.
THE GIFT OF

where I collected it on the morning of September 22, long past flowering (*no. 2011*).* None of the plants were over three or four feet tall. *Elliottia* is a very ordinary-looking bush when not in flower, and might easily be mistaken for something else, particularly for *Diospyros virginiana*, a small form of which sometimes grows in similar situations.

AZALEA CANDIDA Small

Seen only on outcrops of Altamaha Grit, in Tattnall County, June 24 (*no. 1858*) and 26, and in the northeastern corner of Coffee County, September 11. Previously reported only from the type-locality in Lowndes County, but on what formation is not known. At the time I collected it, it was long past flowering; † and the flowers are not yet known, except from a few shrivelled fragments on the type-specimens, which were collected at about the same time of year as mine. This species is probably nearest related to *A. canescens* Mx.

DICERANDRA ODORATISSIMA Harper

Noticed on the sand-hills of the Altamaha River in Liberty County, September 14. Here the corollas were often slightly tinged with pink, making an approach in this respect to the other species of the genus. Captain LeConte's specimen (mentioned in my original description) ‡ may have come from near this place.

PENTSTEMON DISSECTUS Ell.

After having been lost to science for seventy years or so, this species was collected on outcrops of Altamaha Grit near the Ohoopee River in Tattnall County on June 24, in fruit (*no. 1856*), and seen in similar situations in Dooly County on August 29. It has a rather interesting history. It was described by Elliott from specimens sent "from Louisville, Georgia," by James Jackson, § but it is not likely that the specimens were collected close to Louisville, for Mr. M. H. Hopkins, a very observant botanist who has lived in Louisville for years and is familiar with the surrounding country, tells me that he has never seen this plant. But the Altamaha Grit country comes within fifteen miles of Louisville, and if there are any rock outcrops in that part of it, it may have been on one of them that Mr. Jackson found the *Pentstemon.* It was a common practice in Elliott's time (and continues to some extent to the present day, unfortunately) for authors to cite as localities for their specimens merely the nearest town, or the place from which they were sent.

---

* On May 11, 1904, I revisited this spot and found that it had just been burned over and the *Elliottia* completely denuded, but most of the specimens were putting out new leaves again.

† On April 26, 1904, I revisited the spot, and it was just past flowering then.

‡ Bull. Torrey Club 28: 479. 1901.

§ This James Jackson, afterward a professor in the University of Georgia, seems to have been a son of the General James Jackson who was governor of Georgia from 1798 to 1801, at which time Louisville was the capital of the state.

Croom* has published the following note on this species: "Abundant in wet Pine woods, between the Oakmulgee and Oconee Rivers,† Georgia. Flowers in May." His statement that it grows in wet places is rather puzzling (unless perhaps he saw it in rainy weather, when everything was wet), for I find it on dry rocks.‡ And I do not quite understand its being abundant, or growing so far inland.

The fruit of *Pentstemon dissectus* has never been described, but it does not differ noticeably from that of *P. hirsutus* (the common species in Georgia).

UTRICULARIA RESUPINATA B. D. Greene

On the miry margin of a large shallow grassy pine-barren pond in the lime-sink region of Decatur County about two miles southwest of Donalsonville, August 11 (*no. 1925*). Not previously reported from Georgia, or from any other southern state except Florida.

STOKESIA LAEVIS (Hill) Greene

This species has the reputation of being rare, therefore the announcement of a station for it in Georgia may be of interest. On September 9 I collected it in moist pine-barrens in Dodge County near Suomi, in the Altamaha Grit region (*no. 1980*). It was already past flowering.

---

* Am. Jour. Sci. 25 : 76. 1834.

† Doubtless somewhere between the modern cities of Dublin and Hawkinsville, through or near which points Croom is known to have passed.

‡ The same discrepancy exists between the type-habitat and present known habitat of *Gerardia Plukenetii* Ell. See Mohr, Contr. U. S. Nat. Herb. 6 : 727. 1901.

CARPHEPHORUS TOMENTOSUS (Michx.) T. & G.

This species seems to have such a limited distribution in Georgia that a few stations for it may be worth mentioning. I have seen it only in rather dry nearly flat pine-barrens in the lower part of the Altahama Grit region or between that and the coast, in the counties of Appling, Wayne and Pierce. In September, when it was in flower, I saw it at the following places. In Appling: near Prentiss (*no. 1993*), and between Southern Pines and Hurst (two stations on the B. & B. R. R.); in Wayne: near Hortense and Nahunta; and in Pierce, between Offerman and Bristol.

CHONDROPHORA VIRGATA (Nutt.) Greene, Erythea 3: 91. 1895

This little known species has an interesting and rather anomalous distribution and somewhat of a history. The only definite stations for it now on record are in the mountains of Alabama, on Carboniferous sandstone. Its occurrence there has been described or discussed by Mohr,* Kearney † and Harbison ‡; and I have seen an immature specimen collected somewhere in the same region by Eggert. In 1903 I met with it quite unexpectedly in Georgia, two or three hundred miles from the Alabama localities and in very different surroundings from those previously described, but associated with a few of the same species which are said to accompany it in Alabama. I found it only on outcrops of Altamaha Grit, in Tattnall (*no. 1857*) and Dooly (*no. 1855*) counties. At the latter station *C. nudata* (which is very abundant in almost all moist pine-barrens) was growing only a few yards away, but the two species were perfectly distinct, though flowering at the same time. There can be little doubt of the identity of my specimens with those from Alabama, but whether any of these are the same as Nuttall's type is another question, as Dr. Mohr pointed out.

CHRYSOMA PAUCIFLOSCULOSA (Michx.) Greene, Erythea 3: 8. 1895

This, usually considered a sea-beach plant,§ also occurs some distance in the interior. On September 10 I found it at two places on the western border of Montgomery County, on the sand-hills of Gum Swamp Creek (*no. 1986*) and its continuation, the Little Ocmulgee River. The bushes were about a meter tall, and just beginning to flower. In the Torrey Herbarium there is a specimen collected by Croom still farther inland, on the sand-hills of Brier Creek, Georgia (doubtless on the Augusta-Louisville road, near where Richmond, Burke and Jefferson counties meet), and it is mentioned in some of Croom's letters to Torrey.

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* Bull. Torrey Club **24**: 28. 1897; Contr. U. S. Nat. Herb. **6**: 79, 771. 1901.

† Science II. **12**: 833. 30 N 1900.

‡ Biltmore Bot. Stud. **1**: 153. 1902.

§ See Lloyd, Bull. Torrey Club **28**: 445–450. 1901.

ASTER ERYNGIIFOLIUS T. &. G. Fl. N. Am. 2: 502. 1843

Prionopsis Chapmanii T. & G. Fl. N. Am. 2: 245. 1842. Not *Aster Chapmanii* T. & G. Fl. N. Am. 2: 161. 1841.

In moist undulating pine-barrens about a mile east of Recovery, Decatur County, August 14 (*no. 1932*); so rare that I could find only two or three good specimens. This locality is near the extreme southwest end of the Altamaha Grit region. The species has been previously reported only from Florida, but on what formation it is of course not stated.

ANTENNARIA SOLITARIA Rydb.

Abundant at one place in rich shady woods near Cuthbert, July 28 (*no. 1903*). This is the only station known for it in the coastal plain, with the exception of Carpenter's original station in Louisiana,* which probably has not been rediscovered. *A. plantaginifolia*, which I have also never seen farther south, grows in drier places in the same woods.

ACANTHOSPERMUM HISPIDUM DC. Prodr. 5: 522. 1836

Rather abundant in waste places along the river road in the outskirts of Darien, Sept. 16 (*no. 1999*). A native of South America, not previously reported from the United States. It has a very different aspect from its now too common congener *A. australe*, being an erect bushy plant sometimes a meter tall and wide.

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* T. & G. Fl. N. A. 2: 431. 1843. What part of Louisiana is not specified, but a note in Carpenter's handwriting, accompanying the specimen in the Torrey Herbarium, says: "Sides of steep hills, near Jackson, La. Feby. 10th." Jackson (or at least the modern settlement of that name) is in East Feliciana Parish, considerably nearer the coast and farther south than my station, and hundreds of miles from any other known.

A specimen labeled "Ballast ground, Pensacola, Florida," collected by A. H. Curtiss, August 2, 1899 (*no. 6501*, distributed as *A. humile* DC.) is identical with my plant.

HELIANTHUS HETEROPHYLLUS Nutt.

This seems to be quite rare in Georgia. I saw it in September in rather dry pine-barrens near Jesup and Offerman, but not in sufficient quantity to collect.

BALDWINIA ATROPURPUREA Harper

Principally confined to the Altamaha Grit region, but seen also in September, 1903, in the nearly flat pine-barrens of Wayne and Pierce counties, where the Grit may possibly be overlaid by some newer formation. In Wayne County it is quite common, and I secured excellent specimens near Nahunta on the 19th (*no. 2007*). A few days later I found it in two additional counties well within the Grit region, namely, Coffee and Wilcox. Traveling from Douglas to Cordele on the 23d, a distance of about 65 miles through the Altamaha Grit region, I noted this plant seventeen times, between different mile-posts, in four counties. (That such a common, conspicuous and unmistakable plant should have been overlooked until the end of the 19th century is a striking illustration of how little the interior of South Georgia has been explored by botanists.*)

MARSHALLIA RAMOSA Beadle & F. E. Boynton

This recently-described species seems to have considerable variation in habitat. It was discovered in 1900 "in moist, sandy pine-lands at [or near?] Eastman, Georgia." In 1902 I found it in dry pine-barrens in Johnson County,† and in 1903 I found it only on outcrops of Altamaha Grit, in Tattnall (*no. 1855*) and Dodge counties. The latter station is only a couple of miles from Eastman, and therefore somewhere near the type-locality.

MESADENIA DIVERSIFOLIA (T. & G.) Greene

Cacalia diversifolia T. & G. Fl. N. Am. 2: 435. 1843; Chapm. Fl. S. States 244. 1860. Type-locality (according to Dr. Chapman, the discoverer): "Muddy banks of the Chipola River, [near?] Marianna, West Florida."

---

* But that part of the railroad from which these seventeen observations were made did not exist in the summer of 1900, when the species was discovered.

† See Bull. Torrey Club 31: 27. 1904.

Mesadenia difformis Small, Fl. S. E. States 1301. 1903.
Type-locality: Walton County, Florida. (Collected by Curtiss in 1885.)

When I was assisting Dr. Small in preparing a key to *Mesadenia* for his Flora we could find no specimen of *M. diversifolia*, and came very near omitting this species entirely as being too little known. The original specimens, collected by Chapman, must have been lost, as the material so labeled in the Torrey Herbarium represents something very different, and inquiry at the Gray Herbarium failed to reveal anything corresponding to the original description.

But within two weeks after the book was given to the public I unexpectedly received a great deal of new light on the subject. On August 4 I found specimens agreeing exactly with Chapman's description (as far as it goes) in the muddy swamps of Spring Creek at two different places: in Early County near Damascus (*no. 1914*) and in Miller County near Colquitt (*no. 1917*.) A couple of months later I saw in the Biltmore Herbarium a good specimen collected on the muddy banks of the Chipola River near Marianna, Florida (the type-locality, apparently), by C. L. Boynton, August 31, 1899.

One important character can now be added to the descriptions of this species; viz., the involucral bracts have winged keels, as in *M. tuberosa*, *M. Floridana*, and *M. sulcata*. *M. diversifolia* differs from these three species, however, in having the stem merely angled, not furrowed (just as Dr. Chapman indicated), as well as in the lobed upper leaves and in habitat.

M. difformis Small, based on a single immature specimen collected in Walton County, Florida, by A. H. Curtiss in 1885, now proves to be merely a young state of *M. diversifolia*, and must be relegated to synonymy.

As now understood, *Mesadenia diversifolia* has a very restricted range, being known only from Early and Miller counties in Georgia and Jackson and Walton counties in Florida, all of which are wholly or partly in the Lower Oligocene or lime-sink region. It is also to be expected in the intervening counties of Decatur in Georgia and Houston in Alabama.

COLLEGE POINT, NEW YORK.

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LUCIEN M. UNDERWOOD,
Professor of Botany.

COLUMBIA UNIVERSITY,
NEW YORK CITY.

CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 217

A SUMMARY OF CHARLES WRIGHT'S EXPLORATIONS IN CUBA

By LUCIEN MARCUS UNDERWOOD

NEW YORK

1905

[From the Bulletin of the Torrey Botanical Club 32: 291–300. June, 1905]

pam LIBRARY OF THE GRAY HERBARIUM
HARVARD UNIVERSITY.
THE GIFT OF
B. L. Robinson.

[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 32: 291–300, *pl. 21.* 1905.]

A summary of Charles Wright's explorations in Cuba

LUCIEN MARCUS UNDERWOOD

The botanical explorations of Charles Wright in Cuba laid the foundation for our knowledge of the flora of that island, but have left much to be discovered. As will be seen by the following summary, his travels were confined chiefly to the two ends of the island, leaving the great central portion largely unexplored. It is very unfortunate that the labels on his plants, at least in most of the collections where they are to be found, bear only the inscription "Cuba" or "in Cuba orientali." A serial catalogue of Wright's numbers would be of great value, made up from the data on some of the collections where they are to be found. For example, the ferns in Eaton's collection at New Haven bear the data with a much greater degree of fullness, written in from Wright's field-notes, and as Eaton published on the ferns of Wright's collections it is probable that his collection is fuller than any other in existence.* Probably the Grisebach collection of spermatophytes at Göttingen is the most complete for this group, but that of Sauvalle (now at the Estación Central Agronómica in Cuba) is very complete and is said to contain notes showing localities, as would be natural considering the plan Wright had in mind to prepare a flora of the island in connection with Sauvalle.

It appears from Wright's correspondence that a considerable portion of his collection was lost, mainly that collected in the rich tobacco region of the western end of the island (Pinar del Rio). How extensive this loss may have been, probably cannot now be estimated, but it was certainly considerable.† Wright's sojourn in Cuba covered a period of nearly ten years. He arrived in Santiago de Cuba 25 November 1856, and returned to New York 9 September 1857. His second voyage brought him to Santiago 30 November 1858 and he left Havana for New York 28 July 1864. His third trip commenced in May 1865 and he returned in July 1867.

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* Dr. Gray (Am. Jour. Sci. III. 31 : 12. 1886) says that the collection at the Gray Herbarium is "the fullest set," but the ferns at least are better represented at New Haven.

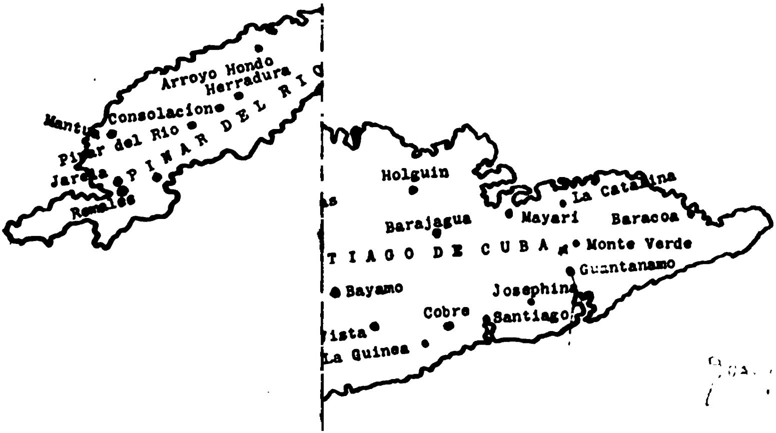
† It seems probable that this loss must have been very great, for we are surprised at the numbers included in his sets. His numbers do not run much above 3,900, and with a flora so large as that of Cuba it seems singular that a professional collector in ten years should not have reached a much higher number, especially as there are numerous duplicates in his collection, at least among the groups of plants with which the writer is mostly concerned. The lower cryptograms were not numbered serially and he

In order to determine more accurately Wright's exact route in Cuba, the writer applied to Miss M. A. Day, the librarian of the Gray herbarium, for information regarding Wright's field notes or other sources of information that might exist at Cambridge. Through her kind intervention, it was made possible to examine the extensive series of letters written by Wright, during his long residence in Cuba, to Dr. Asa Gray. These are now in the possession of Mrs. Gray and it is owing to her generosity that we were able to consult at our pleasure the long series, which consists of some two hundred finely written and often long-continued letters which are full of valuable notes on the flora. The time will come when the publication of these letters, or excerpts from them, will form a valuable commentary on Cuban plants. The tedious perusal of these letters was diversified by Wright's accounts of his experiences, some of which were almost the duplicate of our own, and more especially by the side-notes on the political situation existing in our country during the stormy and tumultuous period of the Civil War (1861–1865). It would appear that Wright was a northern Democrat, and his previous travels in the South had led him to understand the problem from a broader standpoint than many of the residents of New England, whose bias was in great measure due to this lack of exact information of the real situation, and his vigorous statements were evidently called forth by equally strong sentiments from his correspondent.

As we are concerned at present only with the matter of Wright's itinerary, we will cite only the dates and localities where the letters were written, with sufficient of the context to explain the locality and the direction of the course of exploration.

---

was also engaged part of the time in collecting shells and other things, especially after he met Gundlach. In Dr. Gray's *Letters* (2 : 555) these sentences explain the cause of the loss: "April 8th. It grieves my heart and will grieve yours badly when I tell you that your boxes were put under a cargo of wet sugar, which drained into them and have [*sic*] ruined the collection. . . . As to specimens to dispose of, say only one-half or one-third of the whole mass is left fit for it."



Jos[illegible]ina.

La [illegible] Santa [illegible]
en San[illegible] adero.

This list of Wright's stations has been submitted to Professor F. S. Earle, Director of the Estación Central Agronómica at Santiago de las Vegas, Cuba, whose familiarity with the country has enabled him to locate certain places and estates on the map of Cuba that would have been impossible to one less familiar with the geography of the region. In time, it may be possible to locate with accuracy the remaining stations, which are as yet unknown except from the brief and often unsatisfactory hints in Wright's correspondence. The notes added by Professor Earle to the account are marked with his initial — E.

SUMMARY OF CHARLES WRIGHT'S CORRESPONDENCE WITH ASA GRAY

I

1856.	25 N	Santiago.
	6 D	Cobre; written on third day of stay at that place.
	18 D	Filantropia (Mr. Bradford's estate) 12 miles from Cobre "among the mountains."
1857.	15 Ja	Filantropia.
	7 F	Filantropia. Mentions "two high points near here," viz., Nima-nima* and Loma del Gato.
	6 Mr	Filantropia. Speaks of going to Saltadero.
	9 Mr	Filantropia. Had finished packing; had visited 4 plantations.
	14 Mr	Cobre.
	3 Ap	Santa Catalina de Guaso or Saltadero (back of Guantanamo harbor). [Probably = Caimanera. — E.]
	5 Ap	Santa Catalina.
	23 Ap	Monte Verde.
	3 My	" "
	8 My	Saltadero. [Probably the same as Caimanera, the seaport of Guantanamo. — E.]
		[Here occurs a hiatus of four months in the correspondence.]
	9 S	At sea approaching New York.

II

1858.	30 N	Santiago de Cuba.
	5 D	Monte Verde. "Arrived here on 3d."
	17 D	" "
1859.	1 Ja	" "
	17 Ja	" "
	2 F	" "
	15 F	" "
	26 F	" "
	8 Mr	" "
	26 Mr	" "

---

* See below, under Madelina.

	10 Ap	Monte Verde.
	24 Ap	" "
	14 My	Monte Verde. Had collected at La Perla, a neighboring plantation; also speaks of being "within two or three minutes' walk of the virgin forest in every direction."
	21 My	Monte Verde.
	1 Je	Santa Catalina de Guantanamo.
	9 Je	Monte Verde.
	21 Je	" "
	29 Je	" "
	5 Jl	" "
	12 Jl	" "
	16 Jl	" "
	5 Au	" "
	19 Au	" "
	31 Au	" "
	14 S	" "
	17 O	Santiago de Cuba. "Waiting for money" [apparently a chronic condition].
	6 N	Josephina, a hacienda or plantation belonging to the owner of La Perla, three leagues east from Nouvelle Sophie.
	17 N	Nouvelle Sophie. Mentions two excursions to the Farallones from base to summit. [Probably the high mountains east of Santiago. — E.]
	22 N	Nouvelle Sophie. Mentions having left Monte Verde about 17 September.
	26 N	Nouvelle Sophie. Says "protracted stay not advisable."
	9 D	La Madelina, "right at foot of Nima-nima." "Mr. Baitaill tells me that the crest which I have all along on Mr. Bradford's authority called Nima-nima, is La Guinea and that the former is away over towards the seashore."
	24 D	La Madelina. Mentions being at La Guinea 14th and 18th.
	26 D	" "
1860.	10 Ja	Santiago de Cuba. Speaks of going to-morrow to Guantanamo, then to Monte Verde and back by Nouvelle Sophie.
	14 Ja	Monte Verde. "Came from Guantanamo the 11th."
	18 Ja	Nouvelle Sophie.
	21 Ja	Santiago de Cuba.
	2 F	Filantropia.
	24 F	Nouvelle Sophie. "To-day I start for Monte Verde."
	26 F	Monte Verde. Speaks of plan for excursion to Mayari.
	15 Mr	Monte Verde. "I hope you wont let Eaton cut up these fern stems into cross sections. It seems to me simply ridiculous to attempt to exhibit the structure of a fern or palm by a cross section at any part, whereas a longitudinal section of either shows it perfectly, or the whole of it."
	23 Mr	Monte Verde.
	8 Ap	" "
	16 Ap	" "
	1 My	" "
	4 My	Monte Verde. "Monte Verde is nothing but a coffee estate."

[In suggesting labels Wright designates localities under judicial districts "which everybody knows" as follows:

Monte Verde = Yateras.
La Guinea = Ongolosongo [Hongolosonga. — E].
Filantropia = "
Nouvelle Sophie = Las Yaguas.
Josephina = Ramon].

17 My Monte Verde.
14 Jl " "
1 Au Mayari. Mentions conditions of life at Cayo del Rey, where he spent some time.
18 Au Holguin. "Arrived this morning."
(Wright apparently crossed the island directly north of Santiago and then along the north side of the island to Holguin).
22 Au Barajagua. "Left Holguin 19th and arrived here same day."
25 Au Hato del Medio. [Four miles N. W. of Alto Cedro — E.]
9 S Nouvelle Sophie. "Arrived in Cuba (= Santiago de Cuba) the 6th.
13 S Saltadero.
15 S Monte Verde.
18 S Monte Verde. "Start to-morrow for Nouvelle Sophie, thence to Cuba and Bayamo and I may go from there to Holguin."
19 S Saltadero.
20 S Saltadero. "Yesterday started for N. Sophie etc. expecting to get money in Saltadero or Cuba. To-day returned here in chase of that valueless certificate."
17 N San Juan de Buenavista. "S. W. by S. 7 leagues from Bayamo." [Probably S. E. instead of S. W., Buena Vista on new map is about 7 leagues S. E. of Bayamo.—E.]
26 N Bayamo. "Came this morning." *
16 D Nouvelle Sophie. "On my way from Bayamo I turned aside and spent two weeks at Bradford's [Filantropia]. Found a few good things at La Guinea and Loma del Gato."
1861. 4 Ja Monte Verde.
19 Ja " "
27 Ja Nouvelle Sophie.
4 F Monte Verde.
2 Mr " "
13 Mr Potosi (in Mt. Toro). "I am on an excursion through Monte Libano and Monte Toro." [Probably north of Monte Verde.—E.]
25 Mr La Catalina near Sagua de Tanamo. "Tremendous farallones all around us not so easy to climb as you might imagine."
5 My Monte Verde. "Hope to be off to-day or to-morrow for Baracoa."
3 Je Baracoa. "I came from Mata [Probably S. W. of Baracoa; on new map, Mata Cafee.—E.] yesterday, a terribly boggy place and apparently filthy enough to kill mud-turtles. I stood it two weeks or more and I am in good health." * * * "The streams are up preventing me going to the Yunque. † So soon as I can I shall pay it a visit,

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* Dr. Gray (Am. Jour. Sci. III, 31 : 12. 1886) says "his kind host, Dr. Don Manuel Yero, assisted him in making some profitable mountain excursions." Judging from the above dates these must have been very brief.

† El Yunque—the anvil—is a flat-topped mountain six miles from Baracoa—one of the most conspicuous features of the sky line of eastern Cuba.

which will probably detain me but a few days. Then I shall return to Guantanamo stopping a day or two in the cuchillas (mountains)."

24 Je Monte Verde. "Got home yesterday tired out and my horse more so, seven days from Baracoa collecting a little by the way."

29 Jl Monte Verde. "After resting etc. I went on the road to Baracoa as far as the point where it turns northward to cross the mountains."

7 Au Monte Verde.

12 Au " "

4 S " "

5 O Valparaiso. "Just on the edge of Monte Libano." [Seven miles due west of Monte Verde.—E.]

17 O Monte Verde. "Got back yesterday."

24 O " "

24 N Nouvelle Sophie. "On the 20th I set out on my journey which if I am prospered will end at least for a time at "la Habana."

3 D Filantropia. Mentions a day on La Guinea. [Wright then went *via* Saltadero.]

13 D Mentions three excursions on La Guinea and Loma del Gato.

16 D Bayamo. The letter was mailed from Bayamo the 17th.

1862. 2 Ja Sancto Spiritos (Santo Espiritu).

4 Ja Sancto Spiritos "Shall remain a few days" * * * "There are as many as six or eight species of palms abundant along the route I have come, several of which I have not collected."

1 F Ingenio Fermina. "Fermina is a sugar estate two leagues from Bemba" [= Jovellanos.—E.] * * * "Left Santo Espiritu the 16th." [Here Wright found Gundlach, the zoologist, with whom he made many excursions.] In this letter Wright speaks of coming to an ingenio (sugar estate) the 24th where he stayed four or five days and "the next day here." Four leagues before reaching Villa Clara he mentions coming to a very hilly savanna.

23 Mr Mejia. "In my last [there is, however, no mention of this in any letter present in the collection] I told you I was going to the Cienaga de Zapata. I am domiciled about three leagues from it—have been to it twice." [Probably S. of Navajas.—E.]

28 Mr Mejia. "Returned from another excursion to the Cienaga."
[Here occurs a brief hiatus in the correspondence.]

17 Je San José [In Pinar del Rio, near Taco Taco or Santa Cruz.—E.]
[This place is mentioned in a previous letter as away S.W. of Habana.]
"I have been here more than three weeks with Don José Blain, who takes some interest in botany." . . . "I was there (Habana) the last days of May. It's a nasty place." . . . "I am about 20 leagues westward of Habana right at the foot (south side) of Rangel range of mountains or Los Organos."

23 Je "Returned from a visit of two or three days to Retiro, the other place Don José mentioned, when I was in Habana six days."

4 Au Santa Cruz. "Day before yesterday returned from an excursion of a few days south and west of here into the savannas, pinales and the famous 'vueltabago'—the tobacco district." [Properly vuelta abajo.]

13 Au San José.

8 S " "

28 S San José. "Three weeks ago went on an excursion northward and westward; we were gone two weeks."

13 O San José. "Gundlach will send my horses to Guanajay 15 leagues this side of Habana so probably I shall not go there now."

25 O Habana.

29 O San José. "To-day completes my fifty-first year."

27 N San José "Last month went from Guajaibon to Las Posas to Toscana a finca of Sauvalle (seaside) returning by San Marco and San Diego de Bañon. From there I turned S.W., and went to Herradura and Consolacion returning by Almacigos, Hato Queniando, Herradura, San Diego and so home."

10 D Ingenio Esperanza, "about a league from Pinar del Rio."

13 D Langvanillas. [This was probably the residence of an engineer of the above mentioned 'ingenio' about "four leagues away" where Wright mentioned having been invited to go in the last letter.]

1863. 9 Ja San José.

13 F " "

21 F " "

31 Mr " "

10 Ap " "

30 Ap Habana.

14 My — Wright had been at Fermina "for a few days to get plants Gundlach could not bring."

25 My Concordia. "Came here ten days since." Mentions going to the coast three leagues afoot. "Shall return in a few days to San José or rather Retiro whither friend Blain has now removed — a league."

15 Je Retiro. [This is the name of a finca near Taco Taco where Don José Blain lived. — E]

15 Jl Retiro.

27 Jl Toscano. [Probably the name of a finca near the N. coast, somewhat E. of Bahia Honda. — E]

5 S Retiro.

20 S "

20 D Los Remales. "The latter part of October I crossed the mountains to the north coast to Toscano, stayed there till Nov. 15. Went to Sagua (vega) climbed Guajaibon twice; made excursion to Cajalbarra (pine ridge crossing the island) followed down the north side near the coast through La Palma, Nombre di Dios, Bajas, Mantua. From Asiento viego (the Laguna) followed the same road to the Jarela, the terminus of my travels last year." He mentions wanting to go to the cape (Cape Corrientes?) "but as there was no guide I was content to go to a point on the south coast four leagues afoot."

1864. 15 Ja Retiro. "Three days ago I returned from my excursion of eighty," "Wrote 20th from Los Remales: a day or two later went to La Grife." [In this letter Wright mentions a serious experience with some poisonous plant which caused temporary loss of eyesight.]

5 F Retiro.

	14 F	Retiro
	7 Mr	"
	22 Ap	"
	30 Ap	Retiro. "On the 25th went to the coast at a point called Daranigan. [Point on the coast west from Retiro.—E]
	7 My	Retiro. "Yesterday went to the hills."
	19 My	Retiro. "Made an excursion of ten days eastward and southward to La Concordia, San Leon, etc."
	27 Jl	Habana. "Came here on the 21st."
	28 Jl	Habana. "Passport in pocket-book, plants boxed ready to embark,"
1865.	13 Ap	Weathersfield, Conn. "Shall start for Cuba before the end of the month."
	24 Ap	Weathersfield, Conn.

III.

	9 Je*	Cayo Bonito. "Down here on the edge of that grand swamp, the Cienaga de Zapata just south of Matanzas.
	18 Je	La Fermina; "returned yesterday."
	9 Jl	Matanzas.
	24 Jl	Janta. "Came here five or six days ago." . . . "Stayed some ten or twelve days at Palma Sola." [Probably near Matanzas or Jovellanos.—E.]
	15 Au	Matanzas.
	4 S	Habana.
	21 S	Balestina. [At this place the name is spelled Valestina.] † [Province of Pinar del Rio.—E.]
	23 O	"
	7 D	"
1866.	25 Ja	"
	13 F	"
	17 F	"
	15 Mr	Retiro.
	25 Mr	"
	3 Ap	Retiro.
	8 Ap	Toscano.
	14 Ap	"
	29 Ap	"
	2 Je	Retiro. "Left Toscano at 3 m. and arrived here about sunset."
	15 Je	Retiro. "Went to Rangel on the 8th" . . . "*He* went again to San Cristobal on the 10th."
	4 Jl	Retiro.
	23 Jl	"
	8 Au	"
	14 Au	Retiro. "Have been making short excursions of two or three days at a time into the palm and pine savannas near the coast."

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* Dr. Gray *loc. cit.* speaks of this third trip as commenced "in the autumn of 1865." In Gray's letter to Charles Wright (Letters, 2: 540) he mentions receiving a letter from Wright at Habana dated May 9th.

Gray *loc. cit.* says "Balestena" and speaks of it as "a cattle farm at the southern base of the mountains opposite Bahia Honda."

	20 Au	Retiro.
	26 S	"At a sawmill the last two weeks at Palacios" [near Pinar del Rio?].
	10 O	La Machina (this is the sawmill above mentioned).
	28 O	Habana.
	6 N	Retiro. "Spent some days in Concordia."
	2 D	"
	4 D	Retiro. "Yesterday went into the mountains" (La Palma Vega).
	12 D	La Machina. (Various additions to this letter were made from same place at various dates up to 20 D.)
	26 D	Arroyo Hondo. "To-morrow I go to Luis Lazo."
1867.	1 Ja	Guane. "From Arroyo Honda I went to Luis Lazo and staid a few days."
	6 Ja	La Grifa.
	10 Ja	Los Portales de Guane. "Yesterday I left La Grifa."
	21 Ja	Retiro.
	8 F	Habana.
	10 F	Habana. "Went to Matanzas yesterday for money."
	18 F	Habana. In this letter Wright recounts troubles he had to get a passport and other papers necessary to embark for Trinidad.
	19 F	Habana. "Everything arranged for my voyage" [to Trinidad]. [Apparently there is a hiatus in the correspondence here].
	20 Ap	Trinidad. "Since I last wrote you I went in the mountains to an old cafetal now a potrero or pasture. . . . "I came here about a week ago."
	24 Ap	Cuba (= Santiago de Cuba).
	26 Ap	Sta. Catalina de Guantanamo. "Arrived this morning." In this letter Wright mentions "letter of 8th" telling of loss of "great collections of the Vueltabago." [*]
	5 My	Monte Verde. "Back again."
	12 My	" [†]

The next letter is dated Cambridge, Mass., 23 Nov. 1868, in which Wright says "Done distributing." The sets of Cuban plants run thus: 2250, 2200, 2075, 1715, 1550, 1460, 1330, 1275, 1165, 960, 780, 750, 660, 620, 560.

The only breaks in the continuity of the above correspondence are as follows:

1. That from 8 May 1857 at Saltadero to 9 September 1857 written on the steamer approaching New York. This is the longest hiatus, and what may have been Wright's journeys during this period is largely a matter of conjecture. It seems probable that this time, like the rest of his first expedition, was spent on two or three of the plantations that formed the basis of his principal explorations in the province of Santiago.[‡]

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[*] *Cf.* foot-note p. 292.

[†] Dr. Gray (*loc. cit.*) says that Wright returned from his third visit in July 1867.

[‡] Wright's single letter to Dr. Torrey during this period, preserved in the Torrey correspondence at the New York Botanical Garden, is dated 20 June 1857 from Monte Verde and bears out the above supposition.

2. That from 28 March 1862 written near the great swamp south of Matanzas (Cienaga de Zapata) to 17 June 1862 written from the province of Pinar del Rio, where he speaks of having been for "more than three weeks." There is still a hiatus of about two months concerning which we can only conjecture. It seems unlikely that this time was spent other than in the Matanzas province.

3. That from 19 February 1867 to 20 April 1867. At the former date Wright was at Habana making arrangements for a voyage to Trinidad on the south coast, and in the second he was engaged in collecting at Trinidad himself. It would seem that one intermediate letter at least was lost. It is hardly probable from our knowledge of Cuban steamship traffic (which in 1867 was surely not an improvement over the present conditions) that Wright stopped for any length of time at any intermediate station. It is highly probable that the greater part of this time was spent at Trinidad and vicinity covering a period of approximately two months. The amount of material collected at Trinidad may throw some light on this subject, when we know the stations corresponding to Wright's numbers. It is to be hoped that some one who has access to a collection made by Wright which possesses the original localities for the numbers will supplement this paper by further notes which will establish the type localities of Wright's species. Such an account would be a real contribution to our knowledge of the flora of Cuba.

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STIMULATION OF STERIGMATOCYSTIS BY CHLOROFORM

BY MARION ELIZABETH LATHAM

NEW YORK

1905

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 32: 337-351. July, 1905]

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 32 : 337-351. 1905.]

Stimulation of Sterigmatocystis by chloroform

MARION ELIZABETH LATHAM

The response of fungi to the influence of salts and other chemical compounds, as manifested by accelerated growth, increased weight, and active evolution of carbon dioxide, has been the subject of several investigations within a recent period. Raulin's * early observations have been much extended by Richards † who has ascribed ‡ the action to a more economical use of the nutrition at hand, that is, he has proved the economic coefficient of Kunstmann § to decrease as the stimulant approaches its point of optimum efficacy. Ono, ‖ Yashuda,¶ Hattori, ** Stevens,†† Iwanoff,‡‡ Benecke§§ and others have extended the range of toxic compounds, all with concordant results; namely, that those substances which in larger amounts are fatal, serve to stimulate the organism to increase in activity when present in sufficiently small quantities, in accordance with the generalization of Hueppe.[*] In addition, Ono[†] has found that the waste through oxalic acid formation is at the same time lessened; and Watterson[‡] that although there is greater expiration of CO_2 the increase is only parallel with that of the crop and its production relatively normal. Schulz[§] working with yeast; Hueppe,[||] Effront,[¶] and Lindet[**] with bacteria; and Ono[††] and Livingston[‡‡] with algae have reached like conclusions as far as growth is concerned.

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* Raulin, J. Études chimiques sur la vegetation. Ann. Sc. Nat. Bot. V. **11** : 93. 1869.

† Richards, H. M. Die Beeinflussung des Wachsthums einiger Pilze durch chemische Reize. Jahrb. Wiss. Bot. **30** : 665. 1897.

‡ Richards, H. M. The effect of chemical irritation on the economic coefficient of sugar. Bull. Torrey Club **26** : 463. 1899.

§ Kunstmann, H. Ueber das Verhältniss z. Pilzernte u. verbrauchter Nährung. Inaug. Dissert. Leipzig, 1895.

‖ Ono, N. Ueber die Wachsthumsbeschleunigung einiger Algen u. Pilze. Jour. Coll. Sci. Imp. Univ. Tokyo **13** : 141. 1900.

¶ Yashuda, A. On the effect of alkaloids upon some moulds. Bot. Mag. Tokyo **15**. 1901.

** Hattori, H. Studien über die Einwirkung der Kupfersulfats auf einige Pflanzen. Jour. Coll. Sci. Imp. Tokyo **15** : 371. 1901.

†† Stevens, F. L. The effect of aqueous solutions upon the germination of fungus spores. Bot. Gaz. **26** : 377. 1898.

‡‡ Iwanoff, K. S. Ueber die Wirkung einiger Metallsalze und einatomiger Alkohole auf die Entwickelung von Schimmelpilzen. Bot. Centralb. **98** : 97. 1905.

§§ Benecke, W. Die zur Ernährung der Schimmelpilze nothwendigen Metalle. Jahrb. Wiss. Bot. **28** : 487. 1895 ; and Einige neuere Untersuchungen über den Einfluss von Mineralsalzen auf Organismen. Bot. Zeit. **62²** : 113. 1904.

Copeland and Kahlenberg,[||||] and Kahlenberg and True,[***] and more lately Kanda,[†††] working with higher plants tell of stimulation caused by salts. Similarly Copeland[‡‡‡] has obtained increased CO_2 evolution from work with phanerogams and tadpoles, interpretating the apparent vigor, however, as an evidence of harm rather than benefit.

Townsend[§§§] mixed ether with water supplied to seeds and thus hastened germination. He has also shown that seeds, subjected to HCN gas[||||||] for a short time, sprout sooner and grow more rapidly than those not so treated; that *Avena* seedlings grown in a sufficiently weak atmosphere of ether are at first retarded and then accelerated, finally returning to their normal rate of growth if the shock be not too long continued ; and that in small amounts ether vapor will aid germination in the spores of *Penicillium* and *Mucor*,* although larger doses are inimical. Duggar † says that a saturated atmosphere of chloroform is fatal to the spores of *Aspergillus flavus* and *Phycomyces* and without benefit to *Sterigmatocystis*, and that ether is of no consequence as a stimulant in germinating *Aspergillus*. With *Aspergillus* (*Sterigmatocystis*) *niger*, Kosinski ‡ finds respiration retarded when exposed to ether fumes.

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[*] Hueppe, F. The Principles of Bacteriology, 89, 90. Trans. by E. O. Jordan.

[†] *L. c.*

[‡] Watterson, A. The effect of chemical irritation on the respiration of fungi. Bull. Torrey Club 31: 291. 1904.

[§] Schulz. Ueber Hefegifte. Bot. Zeit. 46: 610. 1888.

[||] *L. c.*

[¶] Effront. Compt. rend. 119: 169. 1894.

[**] Lindet. Compt. rend. 138: 508. 1904.

[††] *L. c.*

[‡‡] Livingston, B. E. Chemical stimulation of a green alga. Bull. Torrey Club 32: 1. 1905.

[||||] Copeland, E. B. & Kahlenberg, L. The influence of the presence of pure metals upon plants. Trans. Wis. Acad. 12: 454. 1899.

[***] Kahlenberg, L. & True, R. H. On the toxic action of dissolved salts. Bot. Gaz. 22: 81. 1896.

[†††] Kanda, M. Reizwirkung einiger Metallsalze auf das Wachsthum höherere Pflanzen. Jour. Coll. Sci. Imp. Tokyo 19: 1. 1904.

[‡‡‡] Copeland, E. B. Chemical stimulation and the evolution of CO_2. Bot. Gaz. 35: 81. 1903.

[§§§] Townsend, C. O. The effect of hydrocyanic acid gas upon grains and other seeds. Bot. Gaz. 31: 241. 1901.

[||||||] Townsend, C. O. The correlation of growth under the influence of injuries. Ann. Bot. 11: 509. 1897.

Ewart,§ working with chloroform in the water of water plants noted suspension of CO_2 assimilation agreeing with the earlier results of Claude Bernard. Kegel,|| however, finds with *Elodea canadensis* an increment of CO_2 assimilation in some percentages of ether and chloroform, but a sudden check in the case of a lesser amount. On the other hand, Bonnier and Mangin ¶ were able, by adding ether carefully, to stop assimilation of CO_2 without affecting respiration, an observation in accordance with that of Schwarz,** who, with both ether and chloroform, has recorded stoppage of oxygen evolution not accompanied by elimination of CO_2 evolution until the plant was fatally affected. Ewart's †† results with mosses were similar. Movement in the protoplasm of *Philotria* (*Elodea*),

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[*] Townsend, C. O. Effect of ether upon the germination of seeds and spores. Bot. Gaz. 27 : 458. 1899.

[†] Duggar, B. M. Physiological studies with reference to the germination of certain fungous spores. Bot. Gaz. 31 : 38. 1901.

[‡] Kosinski, I. Die Athmung bei Hungerzuständen u. unter Einwirkung von mechanischen u. chemischen Reizmitteln bei Aspergillus niger. Jahrb. Wiss. Bot. 37 : 137. 1902.

[§] Ewart, A. J. Action of chloroform on CO_2 assimilation. Ann. Bot. 12 : 415. 1898.

[||] Kegel, W. Ueber den Einfluss von Chloroform und Aether auf die Assimilation von Elodea canadensis. Inaug. Dissert. Göttingen, 1905.

[¶] Bonnier, G. & Mangin, L. Recherches sur l' action chlorophyllienne séparée de la respiration. Ann. Sci. Nat. VII. 3 : 5. 1886.

[**] Schwarz, F. Zur Kritik der Methode des Gasblasenzählens an submersen Wasserpflanzen. Untersuch. Bot. Inst. zu Tübingen, 1 : 97. 1881.

[††] Ewart, A. J. On assimilatory inhibition in chlorophyllous plants. Jour. Linn. Soc. 31 : 364. 1896.

as seen by Farmer and Waller,* ceased under the influence of ether and chloroform, the latter proving more powerful.

With various seedlings in an ether atmosphere, Morkowine † obtained increase of respiration in the light; Bonnier and Mangin ‡ got no such effect in the dark. Puriewitsch, as quoted by Morkowine, § concluded that in ether vapor, transformation of sugar to starch is inhibited. Jumelle || believes transpiration increased in light and decreased in dark by ether, Zaleski ¶ that proteid formation is hindered by the same substance. Pfeffer ** cites Elfving †† and Laurén ‡‡ as authorities for the observation that CO_2 formation, but not growth, is augmented in higher plants by a not too long exposure to chloroform; and finally, Johanssen §§ has proved the economic value of ether in forcing early blooming in flowering plants. The period of winter rest is shortened, rapidity of growth and total evolution of CO_2 increased.

The majority of the investigations with chloroform and ether, it will be noted, have had to do with their effect on green plants. Townsend |||| and Duggar ¶¶ to be sure, experimented with fungus spores but their work stopped with germination; and Kosinski *** was concerned only with the respiration factor. It has been the aim of the piece of work here described to compare the effect of chloroform vapor on fungus growth, as shown by increase in dry substance, with the results quoted above. Therefore *Sterigmatocystis nigra* (*Aspergillus niger*) in the main and *Penicillium glaucum*

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* Farmer, J. B. & Waller, A. D. Observations on the action of anaesthetics on vegetable and animal protoplasm. Proc. Royal Soc. **63**: 213. 1898.

† Morkowine, N. Recherches sur l' influence des anesthésiques sur la respiration des plantes. Rev. Gen. de Bot. **11**: 289. 1899.

‡ Bonnier & Mangin, *l. c.*

§ *L. c.*

|| Jumelle, H. Influence des anesthésiques sur la transpiration des végétaux. Rev. Gen. de Bot. **2**: 417. 1890.

¶ Zaleski, W. Zur Aetherwirkung auf die Stoffumwandlung in den Pflanzen. Ber. Deuts. Bot. Gesells. **18**: 292. 1900.

** Pfeffer. Physiology of Plants, **1**: 564. Trans. by Ewart.

†† Elfving. Ueber die Einwirkung von Aether u. Chloroform auf die Pflanzen. Oefversigt af Finska Vetensk. Soc. Forh. **28**: 36. 1886.

‡‡ Laurén. Bot. Jahresb. **20**^{1}: 92. 1892.

§§ Johanssen, W. L. Das Aether-Verfahren beim Frühtreiben. Jena. 1900.

|||| Bot. Gaz. *l. c.*

¶¶ *L. c.*

*** *L. c.*

to a lesser extent were grown on the nutrient solutions prescribed by Pfeffer* and designated as A and C in the first paper on the subject by Richards,† the cultures confined in an atmosphere of chloroform of known or approximately known value and the effect upon dry weight of the crop, economic coefficient and acid coefficient noted.

The work was done in the botanical laboratory of Barnard College during the years 1904 and 1905 under the guidance of Dr. Herbert Maule Richards, to whom his student is much indebted for his kindness and interest. To the New York Botanical Garden many thanks are due for extending the privileges of the library.

To grow the fungi, small dishes 70 mm. in diameter and 30 mm. deep were used. These, in all series following IV, were of the non-sol glass of Whitall, Tatum & Co. Each culture dish rested on two strips of glass over a half Petri dish containing 40 c.c. of a 10 per cent. KOH solution. The Petri dish in turn sat upon a ground-glass plate. On glass strips laid across the culture dish was supported a small watch glass to receive the chloroform. In operating, each dish was arranged as described and all covered by a bell-jar which was ground down on to the glass plate in a glycerine-gelatine seal. After the seal had hardened, amounts of chloroform calculated to the capacity of the jars — due allowance having been made for the solids and liquids within — were run in through the neck which was at once closed with a rubber stopper. It is possible in this way to regulate the supply of chloroform vapor with tolerable accuracy, for the placing of the stopper in position occupies but a moment and relatively little of the chloroform can volatilize and escape. Moreover, the seal at the base of the jar is sufficiently strong to be proof against any small pressure generated by the vaporizing liquid.

In manipulation, the usual precautions were observed. The culture dishes, before each using, were soaked in dichromate cleaning solution, washed, rinsed in distilled and redistilled water and sterilized in hot air at 100°–120° C. The bell-jars were rinsed in formalin ; the glass strips and watch glasses were washed and sterilized in hot air (100°–120° C.). All flasks and pipettes were handled similarly.

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* Pfeffer, W. Ueber Election organischer Nährstoffe. Jahrb. Wiss. Bot. **28**: 205. 1895.

† *L. c.*

The redistilled water mentioned above was the distilled water furnished for ordinary laboratory purposes in the college — the still is tin-lined — redistilled and condensed through a block-tin tube. A considerable portion passing over at first was discarded and the operation stopped while a quantity remained in the distilling flask. This water was used in making all solutions, as well as for the final rinsings of the apparatus. Its specific conductivity as determined in the physics laboratory varied between 2.74×10^{-6} and 1.59×10^{-6}. The salts used were the best quality supplied by Merck & Co. White rock-candy furnished the sugar. A solution of 30–50 per cent. was made, filtered through glass wool to remove the bits of string and kept tightly corked for use. The proper amount from the stock was taken for each solution made for a series. Iron, also, was kept in solution, but the other salts were weighed out as required. The formulae of the solutions are as follows :

A		C	
NH_4NO_3	1.00 gm.	Asparagine	0.50 gm.
K_2HPO_4	0.50 gm.	KH_2PO_4	0.50 gm.
$MgSO_4$	0.25 gm.	$MgSO_4$	0.25 gm.
$FeSO_4$	trace.	$FeSO_4$	trace.
Sugar	5.00 gm.	Sugar	5.00 gm.
Water	100.00 c.c.	Water	100.00 c.c.

The chloroform was the best grade made by Merck, known to contain .02 per cent. of absolute alcohol to prevent decomposition, which, however, in the quantities of the anaesthetic used is negligible. Repeated tests with $AgNO_3$ showed that no free Cl was present.

Sowing the fungus was accomplished by dipping the end of a clean glass rod into the nutrient solution, rubbing it over the dry spores, redipping it into the fluid, and agitating well to secure uniform distribution. The smooth white felts of the control cultures testified to the effectiveness of the treatment and the purity of the reagents. In practice, enough nutrient solution was made at a time for one complete series — the iron alone omitted. This solution was boiled, cooled and 50 c.c. taken in an accurate pipette to be analyzed for acid and sugar. The remainder was then inoculated in bulk with spores in the method described and doses of 50 c.c. run from the pipette into each culture dish. Last of all the iron, a mere trace, was added.

The crop was reaped when the controls showed a full fruited surface. The felts were thrown on weighed filters, washed thoroughly with boiling water, dried in hot air at 70°–80° C., cooled in a desiccator and the dry weight ascertained. The filtrate made up to 250 c.c. was analyzed, as recorded, for oxalic acid, or sugar, or both. Determinations for oxalic acid in the filtrate from the *Sterigmatocystis* * were made at once. Ten cubic centimeters of the solution were titrated against standardized NaOH. The total acidity, less the acidity at the time of setting up (that of the stock solution), gave the correct amount of acid produced during growth.

A measured quantity of the filtrate, generally 100 c.c., was next inverted by boiling with 0.5 c.c. of 5N HCl and the invert sugar estimated by the Fehling test. When asparagine was present, extra care was taken. A cubic centimeter or 1.5 c.c. of acid was used for inversion and the time of boiling extended, water being added if necessary. Asparagine, by virtue of its amide groups, will reduce a copper solution and invalidate a test for sugar in its presence. Hard boiling with HCl serves to destroy the molecule with the production of NH_4Cl, which does not interfere with the analysis. The Fehling solution was kept in two portions. The stock $CuSO_4$ contained 69.28 gms. per liter; the alkaline tartrate, 100 gms. of NaOH and 350 gms. of $KNaC_4H_4O_6$ per liter. Standardization was made against accurately freshly prepared 1 per cent. dextrose. For each analysis 5 c.c. of each stock solution and 40 c.c. of H_2O were used. Calculations were made on the basis that under such conditions 0.5 gm. of invert sugar reduces 97 c.c. of the Fehling solution.†

The fruiting of the control cultures, as mentioned, determined the reaping of the crop. The period of growth varied with the temperature. Near its optimum of 34° C., *Sterigmatocystis* was ready to harvest in seven to ten days when grown on solution A, or in four to five days when asparagine replaced the NH_4NO_3; while the period of cultivation extended over two to three weeks if the temperature fell to 20°–25° C. The lack of constant conditions is to be regretted, especially in view of indications which may be discussed later.

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* Wehmer. Entstehung und physiologische Bedeutung der Oxalsäure im Stoffwechsel einiger Pilze. Bot. Zeit. 49: 1891.

† Sutton. Volumetric Analysis. Ed. 1904.

The first effect of $CHCl_3$ used in such an amount as is necessary to cause noticeable stimulation is to retard the germination of the spores. With the smallest quantities employed, the first hyphae did not appear until six to twenty-four hours after growth had started in the chloroform-free air. The second effect seen is the production of toughened, buckled felts by a rapid growth accompanied by repression of conidial fructification, as observed also when the organism is stimulated by salts, etc. At harvesting, felts grown under optimum stimulation gave on an average crops 200 per cent. to 300 per cent. as heavy as the normal, rising in some instances to 500 per cent. and 700 per cent. The curve representing the influence of $CHCl_3$ on growth is similar to those of other stimulants; it rises in a characteristic manner to a maximum and then falls again.

Sterigmatocystis cultivated on solution A at a temperature varying between 20° and 30° C. grows more luxuriantly when the content of the atmosphere is, per liter, the vapor of $\frac{1}{8}$ c.c. of liquid $CHCl_3$ and the beneficial effect increases until $\frac{1}{2}$–$\frac{7}{12}$ c.c. per liter are used, when decrease begins. If the bell-jar contains per liter over 1 c.c. of $CHCl_3$ (vaporized), germination is permanently stopped, although the spores will grow readily if placed in air. When asparagine, instead of NH_4NO_3, is the source of nitrogen (solution C) the sensitivity of the *Sterigmatocystis* is increased. Optimum growth then takes place when $\frac{1}{6}$–$\frac{1}{4}$ c.c. of $CHCl_3$ is present per liter, and $\frac{2}{3}$ c.c. is sufficient to arrest development.

The augmentation in weight is accompanied by a relatively lessened acid formation and sugar consumption; that is to say, the ratio of the acid to the crop, and of the sugar used to the crop is lowered. For example, in Series X, Table I, the acid coefficient is lowered from 2.3186 to .4160 grams per gram fungus when the atmosphere held $\frac{1}{2}$ c.c. of $CHCl_3$ vaporized and to .3551 grams per gram fungus when the content was $\frac{7}{12}$ c.c.; at the same time, the economic coefficient fell from 11.493 to 3.214 and 3.201 grams per gram fungus respectively. The average figures for the atmospheres quoted are for acid coefficient 0.6932 and 0.5696 and for sugar 3.744 and 3.514 against 1.4123 and 5.358 for the normal culture. The economic coefficient of the controls varies considerably from that found by Kunstmann * and Richards,† to be sure, but the figures obtained are fairly stable. The same thing is true of the data for oxalic acid as compared with those of Ono.‡ That irregular fluctuations may be regarded as due to individual peculiarities is indicated by the consistency in the various factors. For instance, a lack of due increase in weight is, in general, accompanied by an abnormal rise in the coefficients of acid and sugar, pointing to internal differences rather than to errors in calculation or manipulation.

Chloroform belongs to the so-called catalytics in Loew's § classification. The small amount absorbed by the water of the nutrient solution affects the protoplasm so as to cause it to work more economically,. possibly through action on the enzyme formed.|| However that may be, the figures point again to the explanation of the phenomena advanced by Richards¶ and by Ono** as his third alternative, *i. e.*, that the fungus can under the conditions produced by the stimulant thrive more economically.

The sensitivity of *Penicillium* on solution A is about equal to that of *Sterigmatocystis* on solution C.

Another question of interest is the stage in the growth at which the $CHCl_3$ is most potent. To learn this, series were run with the optimum of $CHCl_3$ placed in some when set up as before and in others after the spores had been allowed to start. The former were more prosperous (Table III); that is, the impulse given at germination is more effective than one applied later, but even after complete germination, the fungus responds, although in a lesser degree, in the characteristic fashion.

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* *L. c.*

† *L. c.*

‡ *L. c.*

§ Loew. "Naturliche System der Gift Wirkungen." Munich, 1893, as quoted by Davenport, Experimental Morphology, p. 7.

|| Hueppe (*l. c.*) suggests this vaguely.

¶ *L. c.*

** *L. c.*

That chloroform cannot furnish carbon was settled by sowing spores on a solution of the necessary salts, but omitting sugar, and then placing in optimum chloroform conditions. Not a sign of a germ tube appeared even after two weeks' time.

Although there are no direct data on this point at present, still it is very evident to the worker that a given amount of chloroform is more efficacious at a higher than at a lower temperature, that the optimum point recedes as the temperature rises. It was impossible to keep the temperature of the room in which the cultures were grown constant for any considerable period, but the truth of the statement was many times manifest at various stages in the development. In one or two instances when the crop ripened at from 32–34° C., the optimum was pushed back from $\frac{1}{2}$–$\frac{7}{12}$ to $\frac{5}{12}$ or even $\frac{1}{3}$ c.c. per litre.

The facts indicated are, that:

1. When present in small quantities $CHCl_3$ vapor acts as a characteristic stimulant to the growth of *Sterigmatocystis nigra* and *Penicillium glaucum*.

2. Larger quantities are inimical or fatal.

3. Increased growth is attended by relatively less acid formation and less sugar consumption indicating greater economy in metabolism.

4. The time of greatest sensitiveness is at the germination of the spores.

5. $CHCl_3$ acts as a stimulant purely since it cannot be a source of carbon.

6. The effect of a given amount of the anaesthetic is greater as the temperature rises.

BARNARD COLLEGE, COLUMBIA UNIVERSITY,
April, 1905.

TABLE I.

Sterigmatocystis nigra.—SOLUTION A.

	CHCl$_3$ per li.	Net Weight.	Per Cent. Increase Over Normal.	Oxalic Acid by Weight	Oxalic Acid per gm Fungus.	Sugar Used.	Economic Coefficient. Sugar: Fungus.	Economic Coefficient. Fungus: Sugar.
	c.c.	grams.		grams.	grams.	grams.		
Series I.	0	.5836	—	.3942	.6754	2.7069	4.6378	.2156
Time 14 days.	0	.6628	—	.4097	.6181	3.0790	4.6454	.2152
Temp. 26°–33°C.	$\frac{1}{3}$	.7400	18.74	.2164	.2924	2.1130	2.8554	.3502
10% sugar sol.	$\frac{5}{12}$	.7360	18.10	.1597	.2170	2.2754	2.9820	.3353
	$\frac{1}{2}$	.6838	9.72	.2860	.4182	1.9804	2.8960	.3453
	$\frac{7}{12}$	.7088	13.73	.1468	.2071	1.9885	2.8054	.3564
Series II.	0	.1850	—	.1933	1.044	.7926	4.284	.2334
Time 12 days.	0	.2128	—	.1571	.7382	.8888	4.176	.2394
Temp. 24°–27°C.	$\frac{5}{12}$	.2950	48.31	.3622	1.227	1.3099	4.437	.2254
	$\frac{1}{2}$	.3314	66.62	.2566	.7743	1.5031	5.435	.2204
	$\frac{7}{12}$	.4216	111.9	.2203	.5225	1.6829	3.991	.2505
	$\frac{2}{3}$	.3110	56.36	.1764	.5672	1.3443	4.321	.2314
Series III.	0	.1806	—	.1996	1.105	.7502	4.164	.2407
Time 12 days.	0	.1294	—	.1585	1.224	.5492	4.487	.2228
Temp. 24°–27°C.	$\frac{5}{12}$	.5036	224.9	.1558	.3093	1.5577	3.091	.3309
	$\frac{1}{2}$	.4530	192.2	.1276	.2816	1.3916	3.072	.3255
	$\frac{7}{12}$	.2448	57.93	.0866	.3537	.6952	2.839	.3521
	$\frac{2}{3}$	.1598	3.10	.0618	.3867	.4482	2.804	.4488
Series IV.	0	.1750	—	.1392	.7954	.639	3.651	.2738
Time 12 days.	0	.0790	—	.0928	1.174	.281	3.557	.2811
Temp. 22°–28°C.	$\frac{1}{3}$	.2620	106.3	.1624	.6198	1.084	4.137	.2147
	$\frac{5}{12}$	.2710	113.4	.1753	.6468	1.080	3.985	.2509
	$\frac{1}{2}$	.2100	65.4	.1469	.6995	.833	3.966	.2521
	$\frac{7}{12}$	.2780	118.9	.1469	.5284	1.178	4.237	.2359
	$\frac{2}{3}$	.2226	75.3	.1005	.4535	1.062	4.770	.2096
	$\frac{3}{4}$	.1690	33.1	.1237	.7319	.813	4.810	.2078
Series V.	0	.0920	—	.1391	1.512	.462	5.021	.1991
Time 9 days.	0	.0640	—	.1121	1.751	.353	5.515	.1813
Temp. 26°–31°C.	$\frac{1}{3}$	.1170	50.0	.2589	2.212	.595	5.085	.1966
	$\frac{5}{12}$	.1550	98.7	.2705	1.745	.747	4.819	.2075
	$\frac{1}{2}$	.1370	75.6	.2628	1.918	.704	5.138	.1946
	$\frac{7}{12}$	.1590	103.8	.2551	1.604	.767	4.824	.2073
	$\frac{2}{3}$	.1110	44.3	.2164	1.949	.630	5.676	.1761
	$\frac{3}{4}$	.1750	124.3	.2056	1.174	.837	4.783	.2090
Series VI.	0	.0564	—	.0773	1.371	0.181	3.195	.3130
Time 7 days.	0	.0360	—	.0619	1.719	0.141	3.917	.2553
Temp. 27°–34°C.	$\frac{1}{3}$	.3650	690.0	.2783	0.762	1.480	4.055	.2466
	$\frac{5}{12}$	.2020	337.2	.1739	0.861	0.750	3.713	.2693
	$\frac{1}{2}$	.2720	488.7	.1662	0.611	0.623	2.290	.4366
	$\frac{7}{12}$	.2736	492.2	.1971	0.724	0.976	3.567	.2803
	$\frac{2}{3}$	.2256	388.3	.1469	0.651	0.623	2.761	.3621
	$\frac{3}{4}$	.2246	386.1	.1469	0.654	0.701	3.121	.3204

TABLE I.—*Concluded.*

Sterigmatocystis nigra.—SOLUTION A.

	$CHCl_3$. per li.	Net Weight.	Per Cent. Increase Over Normal.	Oxalic Acid by Weight.	Oxalic Acid per gm. Fungus	Sugar Used.	Economic Coefficient.	
							Sugar: Fungus.	Fungus: Sugar.
	c.c.	grams.		grams.	grams.	grams.		
Series VII.	0	.0200	—	.0541	2.705	.253	12.64	.0791
Time 10 days.	0	.0280	—	.0541	1.932	.290	10.35	.0967
Temp. 24°–30°C.	$\frac{1}{3}$	.1290	437.5	.1852	1.436	.574	4.453	.2246
	$\frac{5}{12}$	.1340	458.3	.0696	0.5194	.518	3.865	.2587
	$\frac{1}{2}$	.1952	713.3	.0812	0.4160	.627	3.214	.3111
	$\frac{7}{12}$	.1960	716.7	.0696	0.3551	.627	3.201	.3124
	$\frac{2}{3}$	.1854	672.5	.0696	0.3754	.653	3.520	.2841
	$\frac{3}{4}$	.1420	491.7	.0501	0.3528	.326	2.296	.4356
Series VIII.	0	.0570	—	.1314	2.305	.343	6.025	.1659
Time 13 days.	0	.0660	—	.1275	1.932	.361	5.462	.1830
Temp. 24°–30°C.	$\frac{1}{3}$	.0980	59.4	.1469	1.499	.488	4.984	.2006
	$\frac{5}{12}$	.1990	223.6	.0696	0.3497	.574	2.885	.3387
	$\frac{1}{2}$	.1810	194.3	.0773	0.4271	.713	3.940	.2538
	$\frac{7}{12}$	.2650	330.9	.0696	0.2626	.701	2.647	.3778
	$\frac{2}{3}$	.1880	205.7	.0503	0.2676	.427	2.287	.4408
	$\frac{3}{4}$	.1130	83.7	.0194	0.1717	.253	2.237	.4470
Series IX.	0	.0820	—					
Time 21 days.	0	.0987	—					
Temp. 23°–25°C.	$\frac{1}{3}$	.1810	101.3					
	$\frac{5}{12}$	.1930	114.7					
	$\frac{1}{2}$	.2508	178.9					
	$\frac{7}{12}$	.1510	68.0					
	$\frac{2}{3}$	.3594	299.8					
	$\frac{3}{4}$	.2390	165.9					

TABLE II.

AVERAGES OF DATA GIVEN IN TABLE I.

$CHCl_3$ per li.	Net Weight.	Per Cent. Increase Over Normal.	Oxalic Acid by Weight.	Oxalic Acid per gm. Fungus.	Sugar Used.	Economic Coefficient.	
						Sugar: Fungus.	Fungus: Sugar.
c.c.	grams.		grams.	grams.	grams.		
0	[illegible]	—	0.1563	1.4123	0.754	5.3579	0.2122
1/3	0.2702	209.0	0.2080	1.1368	1.056	4.2615	0.2388
5/12	0.2987	181.9	0.1796	0.7344	1.101	3.722	0.2771
1/2	0.3015	220.5	0.1756	0.6932	1.047	3.744	0.2924
7/12	0.2998	223.7	0.1490	0.5696	1.077	3.514	0.2966
2/3	0.2518	249.3	0.1174	0.6643	0.741	3.734	0.3076
3/4	0.1771	214.1	0.1091	0.6168	0.586	3.449	0.3239

TABLE III.

Sterigmatocystis nigra.—SOLUTION C.

	$CHCl_3$ per ii.	Net Weight.	Sugar Used.	Economic Coefficient.	
				Sugar: Fungus.	Fungus: Sugar
	c.c.	grams.	grams.		
Series X.	0	0.0596	1.167	19.58	0.0511
Time 7 days.	0	0.0340	1.167	34.32	0.0291
Temp. 25°-32° C.	1/12	0.0210	0.858	40.86	0.0245
	1/6	0 0290	0.858	29.59	0.0339
	1/4	0.1150	1.038	9.026	0.1108
	1/3	0.0720	0.930	12.91	0.0774
	5/12	0.0650	0.832	12.80	0.0781
	1/2	0.1120	0.930	8.303	0.1204
Series XI.	0	0.0886			
Time 7 days.	1/3	0.3106			
Temp. 30°-31° C.	5/12	0.3610			
	1/2	0.2340			
Series XII.	0	0.1910			
Time 4 days.	0	0.1660			
Temp. 32°-34° C.	1/6	0.2810			
	1/4	0.2860			
	1/3	0.1920			
Series XIII.	0	0.4470			
Time 4 days.	0	0.3520			
Temp. 27°-32° C.	1/12	0.2200			
	1/6	0.4660			
	1/4	0.5790			
	1/3	0.2130			
	5/12	0.2120			
	1/2	0.1980			

TABLE IV

Sterigmatocystis nigra.—SOLUTION A

	$CHCl_3$ per lit.	Net Weight.	Oxalic Acid by Weight.	Oxalic Acid per Gm. Fungus.	Sugar Used.	Economic Coefficient.	
						Sugar: Fungus.	Fungus: Sugar.
Series XIV.	c.c.	grams.	grams.	grams.	grams.		
Temp. 24°–31° C.	0	0.1470	0.1276	0.8680	0.477	3.245	0.3082
$CHCl_3$ in before ger-	0	0.0950	0.1044	1.099	0.274	2.884	0.3467
mination, out after ger-	½	0.3200	0.1121	0.3503	0.899	2.809	0.3559
mination, *i. e.*, in 7	7/12	0.1500	0.0348	0.2320	0.365	3.063	0.4110
days. Total time 9							
days.							
$CHCl_3$ after germina-	0	0.0840	0.1585	1.887	0.441	5.250	0.1905
tion, *i. e.*, after 2 days;	0	0.0794	0.1778	2.239	0.365	4.597	0.2175
$CHCl_3$ in 10 days.	½	0.1240	0.0309	0.2492	0.404	3.258	0.3069
Total time 12 days.	7/12	0.2530	0.0619	0.2447	0.640	2.530	0.3953
Series XV.							
Temp 27°–32° C.	0	0.2200	0.1925	0.8750	0.957	4.350	0.2299
$CHCl_3$ in before ger-	0	0.1336	0.2040	1.527	0.777	5.816	0.1719
mination, out after ger-	½	0.2760	0.1584	0.5739	1.015	3.677	0.2719
mination, *i. e.*, in 3	7/12	0.3040	0.1198	0.3941	0.996	3.431	0.2915
days. Total time 7							
days.							
$CHCl_3$ in after germi-	0	0.1780	0.2744	1.542	0.936	5.258	0.1902
nation, *i. e.*, after 2	0	0.1350	0.2435	1.804	0.751	5.563	0.1798
days; $CHCl_3$ in 8	½	0.0490	0.0154	0.3143	0.257	5.245	0.1907
days. Total time 10	7/12	0.0280	0.0193	0.6893	0.257	9.178	0.1089
days.							
Series XVI.							
Temp. 23°–29° C.	0	0.0780					
$CHCl_3$ in before ger-	½	0.3730					
mination, in 4 days.	7/12	0.1700					
Total time 14 days.							
$CHCl_3$ in after germi-	0	0.1190					
nation. In 14 days.	½	0.2000					
Total time 16 days.	7/12	0.2676					
Series XVII.							
Temp. 26°–28° C.	0	0.0674					
$CHCl_3$ in before ger-	½	0.1470					
mination. In 4 days.	7/12	0.1530					
Total time 8 days.							
$CHCl_3$ in after germi-	0	0.1040					
nation. In 12 days.	½	0.0330					
Total time 12 days.	7/12	0.1040					

TABLE V

Penicillium glaucum.—SOLUTION A

	$CHCl_3$ per li.	Net Weight.	Sugar Used.	Economic Coefficient.	
				Sugar: Fungus.	Fungus: Sugar.
	c.c.	grams.	grams.		
Series XVIII.	0	0.0330	0.288	8.727	0.1145
Time 17 days.	0	0.0620	0.397	6.403	0.1561
Temp. 18°–26° C.	$\frac{1}{2}$	0.1320	0.726	5.500	0.1818
	$\frac{1}{6}$	0.1124	0.532	4.733	0.2112
	$\frac{1}{4}$	0.1054			
	$\frac{1}{3}$	0.0950	0.523	5.505	0.1816
	$\frac{5}{12}$	0.0540	0.302	5.592	0.1788
	$\frac{1}{2}$	0.0416	0.257	6.178	0.1618
Series XIX.	0	0.0664			
Time 14 days.	0	0.0930			
Temp. 19°–24° C.	$\frac{1}{12}$	0.0700			
	$\frac{1}{6}$	0.1580			
	$\frac{1}{4}$	0.2980			
	$\frac{1}{3}$	0.0400			
	$\frac{5}{12}$	0.0760			
	$\frac{1}{2}$	0.0400			
Series XX.	0	0.0490			
Time 19 days.	0	0.0534			
Temp. 21°–26° C.	$\frac{1}{12}$	0.0720			
	$\frac{1}{6}$	0.0950			
	$\frac{1}{4}$	0.0580			
	$\frac{1}{3}$	0.0268			
	$\frac{5}{12}$	0.0570			
	$\frac{1}{2}$	0.0300			

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COLUMBIA UNIVERSITY,
NEW YORK CITY.

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB 32 : 451–467. 1905]

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Phytogeographical explorations in the coastal plain of Georgia in 1904

ROLAND M. HARPER

In 1904 my field work was confined to the winter and spring months, in which I had not previously done any work in South Georgia. While collecting timber specimens for the Georgia State Museum I spent a month, from January 23 to February 23 inclusive, in the coastal plain, passing through the counties of Muscogee, Chattahoochee, Marion, Schley and Sumter in January, and Dooly, Wilcox, Irwin, Coffee, Appling, Ware, Clinch, Echols, Lowndes, Brooks, Thomas, Decatur, Miller, Early, Calhoun and Randolph in February. During this period flowering plants numbered *2039* to *2056* and about the same number of fungi and bryophytes were collected. At the same time I made many car-window notes on distribution, mainly of trees and evergreen shrubs.

After completing my work for the State I took the field again on March 25, and before the end of May made notes or collections in the following counties lying wholly or partly in the coastal plain: McDuffie, Columbia, Richmond, Burke, Screven, Bulloch, Emanuel, Jefferson, Washington, Wilkinson, Baldwin, Jones, Bibb, Houston, Twiggs, Laurens, Montgomery, Tattnall, Bryan, Chatham, Liberty, McIntosh, Glynn, Wayne, Pierce, Ware, Coffee, Berrien, Lowndes, Irwin, Wilcox, Dooly, Sumter, Webster, Stewart and Randolph, approximately in the order named. On this trip vascular plants numbered *2057* to *2080* were collected in March, *2081* to *2181* in April, and *2182* to *2232* in May. Seventeen numbers of mosses and thallophytes were collected at the same time.

On both trips, winter and spring together, I traveled about 2500 miles by rail * through the coastal plain, in order to examine as much of the region as possible in its vernal and prevernal aspects. At the same time about 250 photographs of coastal plain vegetation and scenery were taken, with three cameras.

The winter of 1903–4 was colder than usual in Georgia, and spring was consequently late. The first spring flower I noticed was *Alnus rugosa*, on January 23. *Acer rubrum* began to bloom in Coffee County about the first week in February, and *Pieris phillyreaefolia*, *Thyrsanthema semiflosculare* and an unidentified species of *Crataegus* in Lowndes County before the middle of the month. On the Chattahoochee River in Early County *Acer saccharinum* and two or three species of *Ulmus* were just past flowering on February 18, and *Luzula saltuensis* † was beginning to bloom in Randolph County on the 23d. But after April 1st there was no noticeable scarcity of flowers. On that date I found a *Utricularia*, a *Myriophyllum* and a *Potamogeton*, plants which one usually associates with summer, in bloom in Screven County. During the first month after the vernal equinox, before the leaves on the trees were full-grown, I spent most of the time in the Eocene region of the coastal plain, where mesophytic forests prevail (*e. g.*, in the counties of Richmond, Burke, Jefferson, Washington, Wilkinson, Twiggs and Houston), and the woods at that season were resplendent with *Aesculus Pavia*, *Cornus florida*, *Azalea nudiflora* and other characteristic spring-flowering trees and shrubs, much as in the Piedmont region (Middle Georgia) a little farther inland.

Toward the end of April I passed into and through the pine-barren region,‡ where shade and shade-loving plants are scarce, and the most conspicuous flowers do not appear until summer. On a visit to Tybee Island at the mouth of the Savannah River on April 30 I was rather surprised at the scarcity of flowers.

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* For over 600 miles of this I am indebted to the courtesy of the officials of five railroads, the Georgia, the Louisville & Wadley, the Macon, Dublin & Savannah, the Wadley & Mt. Vernon Extension, and the Georgia Southern & Florida, especially the last named.

† See Bull. Torrey Club 32: 154. 1905.

‡ In Georgia the Cretaceous and Eocene regions together constitute about one-fourth of the area of the coastal plain, and the pine-barrens nearly three-fourths.

There seemed to be none at all in the salt marshes, and on the dunes only *Oenothera humifusa*, a *Cakile* and a *Gnaphalium* were noticed in bloom. But in the "hammocks" (low sandy elevations in the salt marshes, covered with evergreen trees and shrubs) *Helianthemum corymbosum* and *Opuntia vulgaris* were in bloom and a *Juncus* and a *Sagina* had already discharged their seeds. On McQueen Island, a brackish marsh eight miles long, midway between Savannah and Tybee, the only flowers visible from the train were those of *Scirpus Olneyi*, a *Hymenocallis* and an *Iris*, and these only at the upper end of the island (where I got off on the way back and collected them).

Most of the places of interest visited in 1904 would have little significance for persons not familiar with coastal plain geography in general and that of Georgia in particular, but there are at least two localities which deserve mention here.

In the southeastern part of Houston County, particularly for two miles north of Grovania and about the same distance south of Elko, much of the surface is strewn with siliceous boulders, and as the topography is at the same time quite rugged, such land is ill adapted for agricultural purposes and still retains its primeval forests. These forests are typically mesophytic, as is usually the case in the upper fourth of the coastal plain, but the abundance of rocks gives them a much more decided Middle Georgia aspect than in most coastal plain forests. I passed through this rocky region on the 15th and 16th of April, about the time flowers are most numerous in such places, and was interested to see such species as *Botrychium virginianum*, *Phegopteris hexagonoptera*, *Stipa avenacea*, *Melica mutica*, *Arisaema triphyllum*, *Luzula campestris*, *Erythronium americanum*, *Vagnera racemosa*, *Uvularia perfoliata*, *Salomonia biflora*, *Medeola virginica*, *Trillium Hugeri*, *T. stylosum*, *Juglans nigra*, *Hicoria ovata*, *Quercus rubra*, *Hepatica triloba*, *Sanguinaria canadensis*, *Geranium maculatum*, *Nyssa sylvatica*, *Oxypolis rigidior*, *Asclepias variegata* and *Chrysogonum virginianum*, none of which range much farther south, while they are more frequent in Middle Georgia or farther north. But the coastal plain character of this region is unmistakably shown by the occurrence, in the same forests, of *Pinus glabra*, *Tillandsia usneoides*, *Uvularia floridana*, *Smilax pumila*, *Myrica carolinensis*, *Magnolia* *grandiflora*, *Acer floridanum*, *Leucothoë racemosa* and *Mesadenia ovata.*

The extent of this formation east and west is unknown, but I have not heard of the occurrence of anything of the kind in any other county. The age of the formation is not definitely known either, but is doubtless either Eocene or Oligocene.

Immediately north of the northernmost of these rocky areas, and perhaps also between them, is a region with strongly calcareous soil and outcrops of soft limestone, characterized by some or all of the following plants: *Taxodium distichum*, *Carex cherokeensis*, *Rhapidophyllum Hystrix*, *Arisaema Dracontium*, *Tillandsia usneoides*, *Trillium lanceolatum*, *Zephyranthes Atamasco*, *Juglans nigra*, *Hicoria ovata*, *Quercus hybrida*, *Q. acuminata*, *Morus rubra*, *Ulmus fulva*, *Crataegus* (several species), *Prunus americana*, *Cercis canadensis*, *Geranium maculatum*, *Ptelea trifoliata*, *Rhamnus caroliniana*, *Viola multicaulis*, *Bumelia lycioides*, *Spigelia marilandica*, and *Phlox divaricata.*

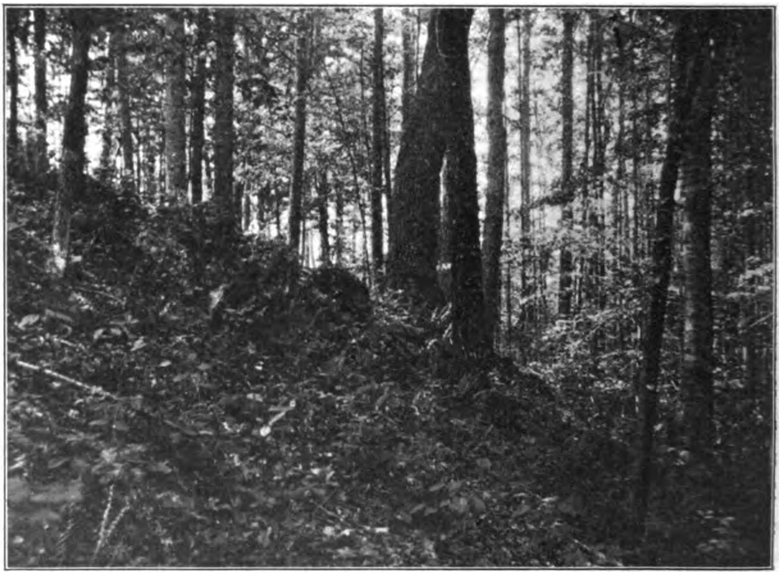

FIGURE 1. View in the rocky woods about a mile south of Elko, Houston County, April 16. Topography and vegetation rather exceptional for the coastal plain. *Polystichum acrostichoides*, *Hicoria glabra*, *Fagus americana*, *Nyssa sylvatica* and *Cornus florida* appear in the view, and the whole aspect of the place is much like that of many points in the Alleghanies and farther north.

This limestone formation seems to form a narrow belt extending from the vicinity of Sandersville through or near Beech Hill, Danville, Westlake,* and Tivola, to Perry and perhaps Marshallville. Some people living near it have an idea that it extends from North Carolina to Mexico, but this is certainly an exaggeration. In Houston County it is commonly known as "the limestone ridge," and is dreaded by farmers who have to haul loads across it in wet weather. At other points where I have crossed it it is characterized by many of the same plants just mentioned, and may be traced by means of them in places where outcrops of the rock are wanting, as in the swamps of the Oconee and Ocmulgee rivers. (See FIGURE 2.) The limestone belt is approximately parallel with the inland edge of the pine-barrens, from which it is distant about ten miles. It is believed to be of Upper Eocene or Lower Oligocene age, but its stratigraphic relations with rocks of the same age else-

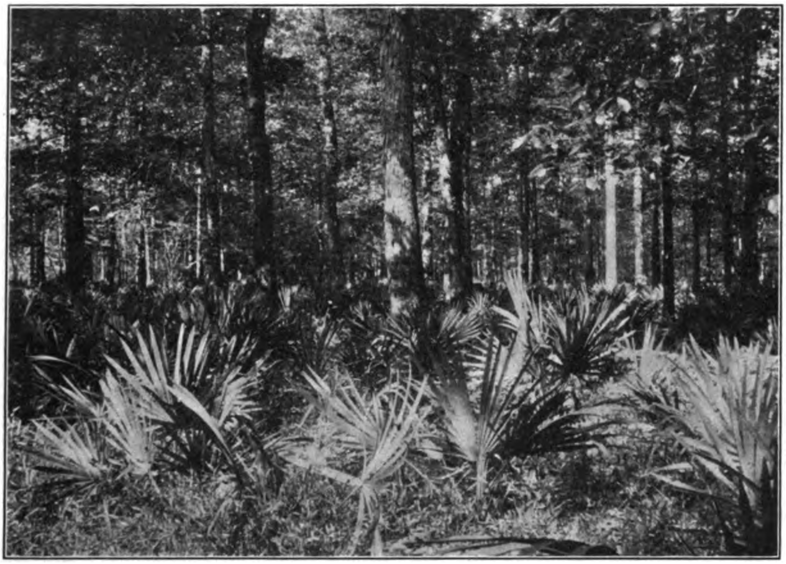

FIGURE 2. Swamp of Oconee River near Beech Hill, Wilkinson County, a point in the limestone belt here described. April 13. The trees are all deciduous, *Quercus Michauxii* being probably the most abundant. The Palmettos are *Sabal Adansonii* and *Rhapidophyllum Hystrix*, the former predominating. *Carex cherokeensis* and other species cover the ground. Shrubs are almost wanting.

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* See Bull. Torrey Club 32: 162. 1905; under *Crataegus georgiana*.

where, and with the siliceous rocks just mentioned, are as yet very uncertain.

In Stewart County there is a remarkable area of genuine pine-barrens, which I first noticed in 1901,* and examined more carefully in the latter part of May, 1904. It is situated immediately south of Omaha, on a plateau which is bounded abruptly on the north by Hannahatchee Creek, and on the west by the Chattahoochee River bottoms, and is elevated something like 100 feet above both streams. The southern and eastern limits of the plateau have not been ascertained, but the pine-barrens occupy at least a square mile in the northwestern corner of it. What makes this pine-barren area remarkable is the fact that it is well within the Cretaceous region (having unmistakable exposures of Cretaceous rocks north, south, east and west of it) and is separated from the rest of the pine-barrens by the whole width of the Eocene and part of the Cretaceous, a distance of thirty or forty miles. Although *Pinus palustris*, the characteristic tree of the pine-barrens, is scattered more or less over the whole Cretaceous region of Georgia, yet nowhere else in that region have I seen it constituting the bulk of the forest as in the place here described. In the Eocene region it is still rarer, and one may go from Cuthbert twenty miles northward on the road to Lumpkin without seeing a single specimen of it, its place being taken there mostly by *P. echinata.*

The pine-barrens near Omaha are nearly level, and contain several ponds, at least one of which probably holds water all the year round. (See FIGURE 3.) The whole aspect of the place is much like that of some of the pine-barrens in the Lower Oligocene region (in Sumter County, for instance), and totally unlike that of the typical Cretaceous country, which is carved into broad valleys and rather narrow ridges, indicating a comparatively ancient topography. The long-leaf pines grow fully as large as they do anywhere, and I measured a stump of one which was 38 inches in diameter. The pines of low grounds are *P. serotina* and *P. Taeda*, instead of *P. Elliottii*, which ranges throughout the typical pine-barrens in similar situations. The following shrubs and herbs are common to this area and the typical pine-barrens, and are rare or wanting in the Eocene and the rest of the Cretaceous: *Anchistea vir-*

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* See Bull. Torrey Club 30: 287, 325. 1903.

ginica, *Scirpus cylindricus*, *Xyris Smalliana*, *Eriocaulon compressum*, *Pontederia cordata*, *Pogonia divaricata*, *Brasenia purpurea*, *Polygala lutea*, *Hypericum fasciculatum*, *H. acutifolium*, *Rhexia glabella*, *Persea pubescens*, *Proserpinaca pectinata*, *Limnanthemum aquaticum*, *Vaccinium nitidum*, *Gratiola pilosa*, *G. ramosa*, *Monniera caroliniana*, *Utricularia purpurea*, *Houstonia rotundifolia*, *Viburnum nitidum*, *Sclerolepis uniflora* and *Sericocarpus bifoliatus*. Two of these, *Anchistea* and *Monniera*, are reported in Mohr's Plant Life of Alabama as having been collected by Dr. E. A. Smith in the neighboring counties of Russell and Barbour in Alabama.

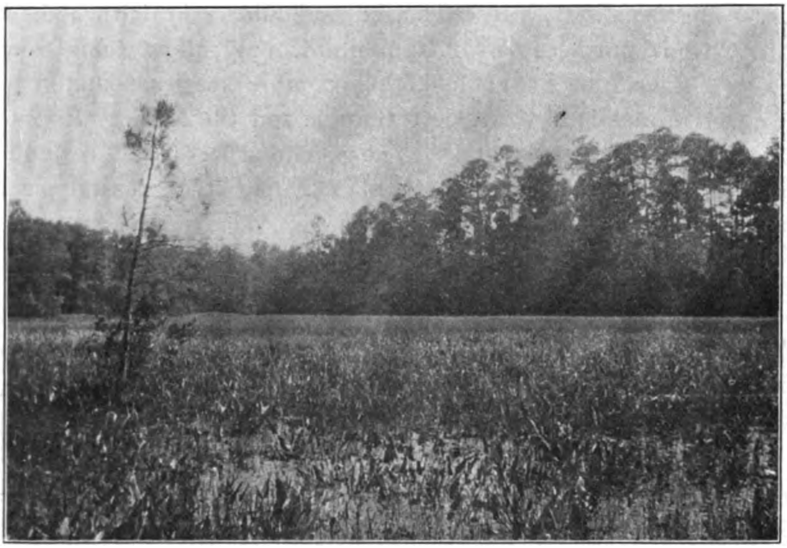

FIGURE 3. "Alligator Pond," in the outlying pine-barrens near Omaha. May 24. The tree in the left foreground is *Pinus serotina*, and most of those in the distance are of the same species. *Pontederia cordata* conspicuous in the foreground. (For a list of some other species observed in the same pond, see Bull. Torrey Club 30: 325. 1903.) The demarcation between the pond vegetation and the surrounding shrubbery is much more abrupt here than in typical pine-barren ponds, and suggests the glacial lakes of the northern states.

Now as for the cause of these outlying pine-barrens. The two superficial formations, Lafayette and Columbia, are present, as in the typical pine-barrens and most other parts of the coastal plain, but these rarely if ever determine the topography. The conclusion is irresistible that we have here between the Lafayette and Cretaceous strata an outlying patch of some Tertiary formation. Dr.

Smith suggests that it may be the Grand Gulf, which he finds to overlap a good deal of the Cretaceous and Eocene in Alabama; but the topography is not exactly that of the Altamaha Grit, which in Georgia corresponds to the Grand Gulf formation in Alabama and westward. Future explorations will probably settle this point.

The following plants of special interest were observed in South Georgia in 1904:

PELLAEA ATROPURPUREA (L.) Link

Collected on May 26 on limestone boulders in rich woods in the extreme northern part of Randolph County, about a mile from Grier's Cave (no. 2231), making one more species common to Pigeon Mountain in Northwest Georgia and the Midway Eocene region of Randolph County.* The general aspect of its surroundings is much the same at both places. No other coastal plain station for *Pellaea* seems to be known.

? SPARTINA JUNCIFORMIS Engelm. & Gray

On May 3, while approaching Brunswick, I saw from the train just outside of the city a quantity of an unfamiliar grass, and on investigating the next day I found it to be a *Spartina* (*no. 2187*), with slender erect stems 5 or 6 feet tall, growing in dense tufts of several hundred each. Its inflorescence is most like that of *S. junciformis*, a species of the Gulf coast, but it can hardly be that or any other described species. The leaves of my plant are concave, but not involute when fresh; and there is nothing in the existing descriptions of *S. junciformis* to indicate that it grows in such large tufts. (But probably most of these descriptions are drawn entirely from herbarium specimens, as is too often the case.) The habitat of my plant was very unusual for a *Spartina*, being a sort of combination of cypress (*Taxodium imbricarium*) pond and pine-barren stream, though probably only a few feet above tide-water. All the specimens seen were within about a hundred yards of each other.

SCIRPUS FONTINALIS Harper, Bull. Torrey Club 30: 322. 1903

This species, previously known only from the type-locality in Sumter County, has turned up at two more South Georgia stations, quite different from the type-locality as well as from each other. On April 16, I found a few specimens beginning to flower (*no. 2130*), around a spring in the rocky woods mentioned above, about two miles south of Elko in Houston County. On May 3, I collected it again in low woods near Thalmann, Glynn County, where it was more abundant (*no. 2185*). Here it was associated with *Sabal Palmetto*, *S. Adansonii*, *Cladium effusum*, *Itea virginica*, *Rubus nigrobaccus*, *Acer rubrum*, *Pieris nitida*, *Viburnum nudum*, and some other species which seemed strangely incongruous; while at the Houston County station some of its nearest neighbors were *Hepatica*, *Sanguinaria*, *Geranium*, and other familiar northern plants. The three known localities have probably at least one feature in common however, the absence of the Lafayette formation and consequently more or less calcareous soil.

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*See Bull. Torrey Club 31: 16. 1904.

The specimens of these later collections have culms ascending or nearly erect (not nodding as in the type), and shorter and less densely tufted than in the original specimens; no tendency to proliferation in the inflorescence was observed (though this may develop later in the season); and the type specimens were evidently somewhat abnormal in these respects. The new specimens seem to be just as distinct from related species as the old ones were.

CLADIUM MARISCOIDES (Muhl.) Torr.

This is probably common enough in the glaciated region of the North, but very few stations are known for it in the South.* Consequently I was rather surprised to find a good deal of it in a grassy cypress pond between Pinehurst and Unadilla in Dooly County on May 21 (*no. 2221*). It was then not quite in flower.

The leaves of this species are different from any others known to me, and I have never seen them correctly described. Toward the base they are channeled, and a cross section there would show a shallow trough with flat bottom and erect sides. Tapering upward, the leaf gradually folds inward on its midrib, and within an inch or so of the apex the margins (remaining about the same width) become completely united, giving there a triangular cross section.

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*See Rhodora 1: 43, 98, 204; 2: 123, 202; 5: 133; 6: 108; 7: 72; also Mohr, Contr. U. S. Nat. Herb. 6: 410. 1901

CAREX SQUARROSA L.

A few specimens were collected in the swamp of the Ocmulgee River at Barrow's Bluff (the present northern terminus of the Wadley and Mt. Vernon Extension R. R.), Coffee County, on May 14 (*no. 2204*). Its occurrence there is rather anomalous, for it had not previously been reported south of the mountains of Georgia; but it is unquestionably indigenous.

CAREX WALTERIANA Bailey (*C. striata* Michx.)

With *Cladium mariscoides* (see above), also in pine-barren ponds in Screven (*no. 2090*) and Irwin counties in the Altamaha Grit region. Seen in 1903 in the eastern part of Effingham County (*no. 1810*). Not at all common.

The perigynia of this species are described in Small's Flora, and perhaps elsewhere, as "purple-brown," but they are really pale-green, just as in most species with inflated perigynia.

CAREX sp.

On May 4, I collected in a cypress pond just outside of Brunswick some over-ripe specimens of a *Carex* (*no. 2186*) which does not seem to be provided for in modern books. I at once recognized it as a species I had often before seen in summer after its fruit had all fallen, and had never collected for that reason. I afterward saw it in a number of similar places in the pine-barren region. It is so common that it must have been seen by many botanists in the past, and it has probably been described, but it is practically impossible to decide what name, if any, should apply to it. I will describe it briefly here so that future monographers may recognize it and perhaps place it correctly. It is a near relative of *C. glaucescens* Ell. or *C. verrucosa* Muhl. (if these are synonymous; if they are not, it may be identical with one of them), but differs from the plants to which these names have been usually applied in having the pistillate spikes on stout nearly erect peduncles, and flowering always about three months earlier (*i. e.*, in March or April, like most *Carices* in that latitude).

CAREX CHEROKEENSIS Schw.

Seen on April 13 and 15 at two points in the limestone belt above mentioned, namely, in the Oconee River swamp near Beech

Hill, Wilkinson County (*no. 2116*), and in rich woods between Tivola and Beech Haven, Houston County. At the former station (see FIGURE 2) it and several of its congeners were quite abundant. This is one of the few *Carices* which shows a decided preference for calcareous soil. It does not seem to have been reported from the coastal plain of Georgia before (though I collected it in Sumter County in 1900), but it has long been known from the Palaeozoic region (Northwest Georgia), where it seems to have been first discovered.

In the description of the species in Small's Flora the word staminate is inadvertently used instead of pistillate, and in the key the descriptive phrase "Leaves pubescent" belongs to the northern representative of the group *Flexiles* (see Britton's Manual, page 206), and not to *C. cherokeensis*. This gave me some trouble in identifying it. The following characters might well be added to the existing descriptions of this very distinct species: — Rootstocks stout, elongated, horizontal, partly covered with the rigid persistent bases of the leaves; leaves smooth and shining, tough, purple at base.

CAREX RENIFORMIS (Bailey) Small

With or near several of its congeners (but perfectly distinct from any of them) in the swamp of the Ohoopee river near the center of Tattnall County, April 26 (*no. 2153*). Previously known only from Mississippi and Louisiana.

ERIOCAULON LINEARE Small, Fl. S. E. U. S. 236. 1903

This was one of the greatest surprises of the whole trip. It was originally described from a few specimens collected in wet woods in the pine-barrens in the upper part of Bulloch County in June, 1901; and I never saw a trace of it again until April and May of last year. Then I was astonished to find it one of the most abundant plants in moist pine-barrens in the Altamaha Grit region, growing in countless millions in Bulloch, Tattnall, Montgomery (*no. 2146*), Coffee, Wilcox, Irwin, Berrien, and doubtless many other counties. Its habitat is exactly that of the well known and larger *E. decangulare*, which is equally abundant and conspicuous during the summer months. *E. lineare* seems to flower only in April and May (the type specimens, collected early in June, were past their prime), and after that its scapes must disappear almost completely, and the leaves alone would attract no attention. When it is in flower *E. decangulare* can usually be found with it, but very immature and inconspicuous, and when the latter blooms the former is almost invisible. How such an abundant species as *E. lineare* could have been overlooked so long can be explained only on the supposition that it is nearly confined to the Altamaha Grit region, which up to last year had scarcely been explored in spring.*

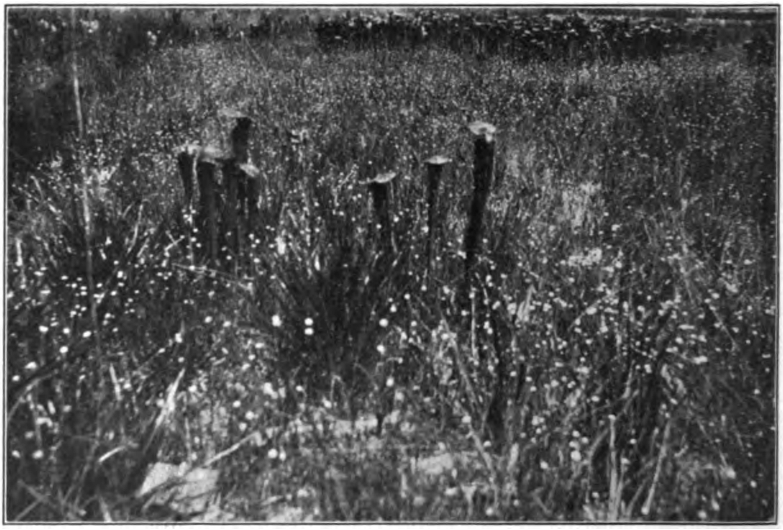

FIGURE 4. *Eriocaulon lineare* in moist pine-barrens, Douglas, Coffee County. May 16. Two months later in the season *E. decangulare* can be found equally abundant on the same spot. (The pitcher-plants are *Sarracenia flava* in the background and *S. flava* × *minor* in the foreground.)

If the plant had ever been seen by other botanists it was probably mistaken for *Lachnocaulon anceps* or *Dupatya flavidula*, which often grow with it and are about the same size. In its own genus it is probably nearest related to *E. compressum*, a considerably larger plant which flowers still earlier, in March and April, and grows almost always in pine-barren ponds. *E. septangulare* is nearer to it in size, but is rare in the South, growing on sandy margins of ponds and flowering in late summer.†

With more copious material at hand, the resemblance of *E.*

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* See Bull. Torrey Club 32: 142. 1905.

† See Bull. Torrey Club 31: 14. 1904.

lineare to a plant from Sumter County (*no. 1395*) which I had distributed in my 1902 collection as *E. texense* Koern. * seemed very strong, so on May 21 I revisited that locality and collected some more specimens (*no. 2219*) on the same spot. These proved to be *E. lineare*, as I suspected; so *E. texense* seems to be known only from the original collection, after all.

I notice an unfortunate typographical error in the original description of *E. lineare*. At the end of the first line, "alternate" should be "attenuate" (referring, of course, to the apex of the leaf).

ALETRIS OBOVATA Nash; Small, Fl. S. E. U. S. 286. 22 Jl 1903
(Described more fully in Torreya **3**: 101, 102. 25 Jl 1903)

This is the common if not the only white-flowered *Aletris* in the Altamaha Grit region. In May I saw it in the counties of Ware, Coffee (*no. 2201*), Wilcox, Irwin and Berrien, in rather dry pine-barrens. It was previously known only from the type-locality in northeastern Florida.

Dr. Chapman describes the flowers of both *A. aurea* and *A. farinosa* as either white or yellow, but it is now pretty evident that his yellow *farinosa* was *A. lutea* Small,† and his white *aurea*, *A. obovata* Nash; so the description of these two newer species has considerably facilitated our understanding of the genus. Like *A. lutea*, which often grows with it, and blooms at the same time, *A. obovata* differs from *A. farinosa* in range and from *A. aurea* in time of flowering.

With *A. lutea* and *A. obovata* at the place where I collected the latter (near Douglas) were a few specimens intermediate in appearance, probably hybrids.

HYMENOCALLIS sp.

At the end of April a *Hymenocallis* (*no. 2179*) in full bloom was conspicuous in the brackish marshes at the upper end of McQueen Island in Chatham County, about five miles from Savannah by the Tybee Railroad. It had only one or two flowers, usually two, on each scape, and the leaves were only about 2 cm. wide. This plant seems to have been known to LeConte, Feay, and some of their predecessors, but in the present state of the literature bearing on the genus it is difficult to decide whether it has ever received a tenable name. It is certainly distinct from a species which grows in shady swamps in the Lower Oligocene region and has broad leaves and three or four flowers, blooming in July; but there are probably not more than three species of *Hymenocallis* in the southeastern states outside of Florida, and one of them is very local, growing only along the fall-line. These three species are recognized in Mohr's Plant Life of Alabama, but it is not certain that they are correctly named there. The study of this genus is complicated by the fact that some species are said to produce more flowers in cultivation than in the wild state, and several of them were first described from cultivated specimens.

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* See Bull. Torrey Club 31: 20. 1904.

† See Bull. Torrey Club 32: 154. 1905.

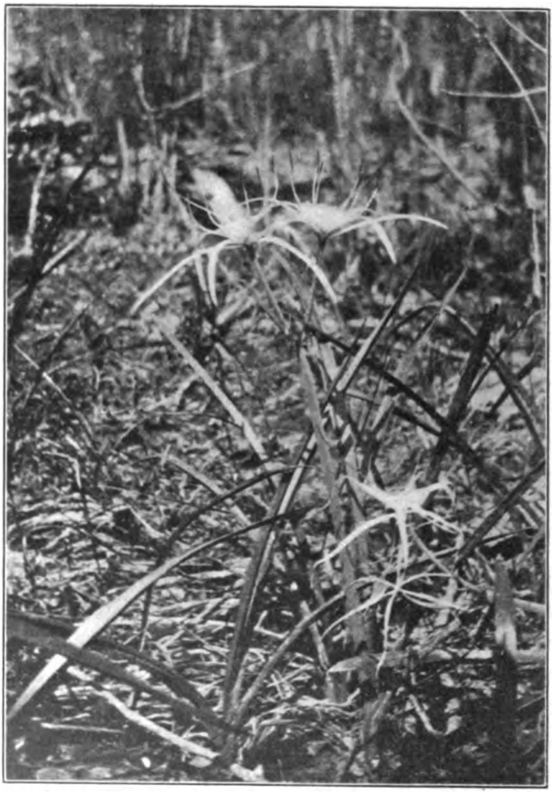

FIGURE 5. *Hymenocallis* sp. in Seventeen Mile Creek, Coffee County. May 12. The creek was very nearly dry at the time, but water often covers this spot.

What seems to be exactly the same plant was seen in a creek swamp in Coffee County in May, and the illustration of it subjoined (FIGURE 5) may enable some future monographer to determine the species.

QUERCUS GEMINATA Small, Bull. Torrey Club **24**: 438. 1897

This has been known hitherto only as a shrub or small tree, ranging from Florida to Mississippi. While collecting timber specimens in the winter I had occasion to study the live-oaks on the sand-hills of the Altamaha Grit region, and found them to be all of this species. In Coffee County (*no. 2050*) it is sometimes thirty feet tall, with a trunk two feet in diameter, which when full grown is never erect, but ascending or curved.

Its distribution has not been well worked out yet, but it can probably be found in every county in the lower half of the coastal plain of Georgia. *Q. virginiana*, with which it was formerly confused, seems to be confined to the immediate vicinity of the coast and to the lime-sink region (which are just the regions where *Tillandsia usneoides* grows most luxuriantly). These two oaks are not as distinct as one might wish, however, and on Tybee Island I have seen specimens which might be referred about equally well to either.

CLAYTONIA VIRGINICA L.

In the swamp of the Oconee River near Beech Hill, Wilkinson County (see FIGURE 2), April 13 (*no. 2120*). This is the only place where I have seen it in the South. Its habitat is certainly very different there from what it is in New York City, where it is almost a weed.

SAGINA DECUMBENS SMITHII (Gray) Wats.

What seems to be this little-known plant was collected in a hammock (see page 453) on Tybee Island on April 30 (*no. 2175*). It was past flowering, but was readily distinguishable from *S. decumbens* by its almost simple, strictly erect, purple stems. It was previously known only from the coastal plain of New Jersey, and adjacent Pennsylvania.

There are a number of plants on the sea islands of Georgia, growing in apparently perfectly natural places, whose indigeneity* is doubtful, and this is one of them.

MAGNOLIA ACUMINATA L.

Collected in rich woods at the extreme coastward edge of the Cretaceous region, about two miles northwest of Lumpkin, May 25 (*no. 2227*). I saw only one tree, but was informed by a native that there is a good deal of it in the vicinity, and that its wood is a favorite material for hoe-handles.

SAXIFRAGA VIRGINIENSIS Michx.

On sandstone rocks on a bluff along McBean Creek in the southeastern corner of Richmond County, March 26, in flower (*no. 2061*). This station is in the Eocene region, about twelve miles below the fall-line, and seems to be the only one known for this species in the coastal plain.

DIRCA PALUSTRIS L.

On the sandy bank of the Oconee River opposite Dublin, Laurens County April 20 (*no. 2136*). This locality was pretty well exposed to the sun, and is rather a remarkable one for a species which in New England prefers the coolest and shadiest places.

AESCULUS PARVIFLORA Walt.

In rich shady woods at two or three places between Lumpkin and Omaha, in Stewart County, in the Cretaceous region, May 24 and 25, with flower-buds very immature (*no. 2225*). I do not know of any other station in Georgia for it. The habitat and time of flowering given for this species by Chapman and Small seem to need some revision.

POLYCODIUM REVOLUTUM Greene, Pittonia **3**: 325. 1898

On the sand-hills of the Allapaha River in the northeastern part of Berrien County, May 5 (*no. 2191*). A shrub about 6 feet tall, copiously branched. Previously known only from the type-locality in Lake County, Florida. This species is not mentioned in Small's Flora, but seems as distinct as any of those into which this little genus has recently been divided.

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* I do not find this word in the dictionaries, but it appears in the *Journal of Botany* for March, 1905 (page 90), if not elsewhere, and there seems to be no other word to express the same idea.

LEPTOPODA HELENIUM Nutt. Gen. 2: 174. 1818

Frequent in moist pine-barrens and shallow ponds in various parts of the coastal plain, flowering in April and May. Collected in Bulloch (*no. 2167*) and Sumter (*no. 2213*) counties. This certainly seems generically distinct from *Helenium*, in which it has been placed by many authors; but I am unable so far to distinguish more than one species of *Leptopoda*.

COLLEGE POINT, NEW YORK.

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Lists of titles of Contributions may be had on application.

LUCIEN M. UNDERWOOD,
Professor of Botany.

COLUMBIA UNIVERSITY,
NEW YORK CITY.

EIVED.
23 1905

CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 220

THE ARTIFICIAL INDUCTION OF LEAF FORMATION IN THE OCOTILLO

By FRANCIS E. LLOYD

NEW YORK

1905

[From Torreya 5: 175-179. O 1905]

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HARVARD UNIVERSITY.
THE GIFT OF

THE ARTIFICIAL INDUCTION OF LEAF FORMATION IN THE OCOTILLO*

By Francis E. Lloyd

The post-pluvial appearance of foliage within a very short time upon desert plants which remain through periods of drought in a leafless condition is a phenomenon which has very often been remarked. The behavior in this regard is most striking in deserts, where there is prolonged lack of rain. Although in some regions the rain penetrates into the ground very rapidly, nevertheless it has seemed improbable to many, no doubt, that the absorption of this water from the soil alone gives the necessary stimulus to leaf formation. Led by this idea, attempts have been made to find in many of the superficial structures of plants the means for the absorption of water, or water vapor, and it may very well be that experimental research will in the future throw light upon the extent of adaptation, as evidenced by anatomical structures, to which plants have attained in this matter. It was during a conversation upon such points with Dr. W. A. Cannon at the Desert Botanical Laboratory that the suggestion was made by him that it would be instructive to see if any light could be obtained upon the influence of meteoric water upon the development of leaves in *Fouquieria splendens*, the ocotillo of the southwest. I accordingly planned three experiments which were carried out upon a perfectly leafless plant, all alike in principle, but differing in details. In one case, the only one I shall describe, a reservoir, consisting of a gallon bottle, was attached to the neighboring limbs of a "palo verde," and a siphon arranged to lead water to a string of cheese-cloth, which in turn led the water to a bandage of the same cloth tied about a stem of the ocotillo three feet from the ground. The fierce winds several times played havoc with my arrangements, but finally I managed to adjust the apparatus to the swinging of the stems by allowing slack in the cheese-cloth string. The siphon ended in a capillary tube, so that the flow of water was small and, while it ran down the ocotillo stem at times, it did not reach the ground in any case. The reservoir was replenished daily, but the flow of water was discontinuous. The result was, of course, a closer simulation of the actual occurrences at the time of the rainy season.

---

* This work was done at the Desert Botanical Laboratory, Tucson, Arizona, under a grant from the Carnegie Institution, of Washington, during the summer of 1905.

The first run of water was applied on the morning of the first of July, and this was repeated each day. The stem was thus kept more or less wet for half the time. On the evening of the fourth, the leaves along 12–15 inches of the stem below the bandage showed marked development, being 1 centimeter long; and by the sixth of July, at three P. M., their length was 1.5 centimeters. On July 9, the largest leaves were 2 centimeters long, and the branch in question, together with its neighbors were photographed (FIG. 1). In looking at this picture one must realize that all the stems shown were at first equally leafless. It will be instructive to compare the above facts with those observed after rain.

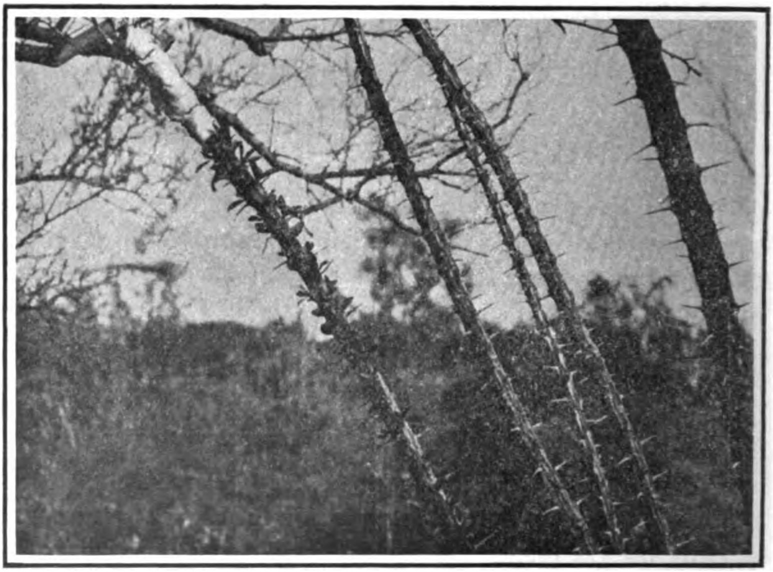

FIG. 1. *Fouquieria splendens*, showing a branch which had been irrigated during four days.

On July 11, at 5 P. M., we had the first shower of the rainy season, the amount of precipitation being one and one-tenth inches within two hours, drenching, of course, all the vegetation. On the following day (the 12th) at four P. M., it was quite evident to the eye that the buds had made a start. By July 13, the slender conical buds along the whole extent of the stems were 7 to 8 millimeters long. On July 14 at five A. M., the rosettes of leaves were well formed; the length of the largest leaves was 1.5 centimeters, their size being, however, quite uniform. On July 15, the photograph forming the second figure was taken. It will be noted that the leaves on the irrigated stem were at that time much larger than the freshly formed leaves, that is, those produced after the rain, and as a result of the stimulus thereby given.

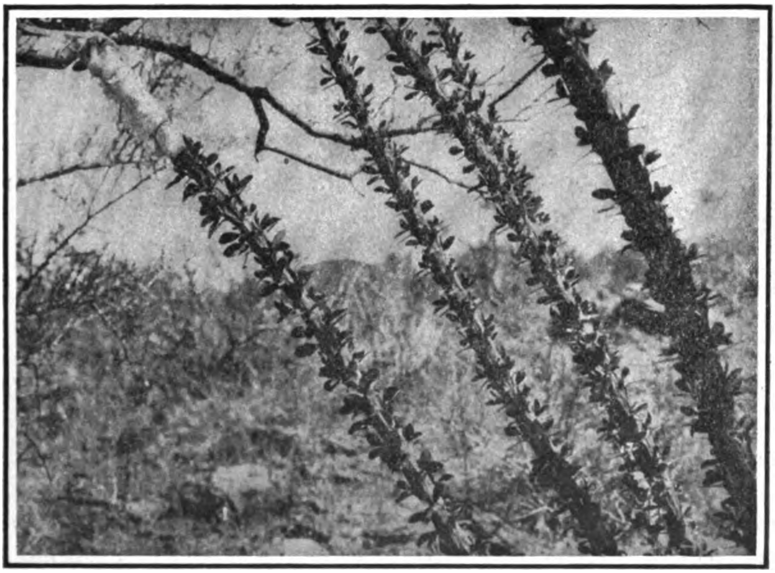

FIG. 2. *Fouquieria splendens* — the same as in FIG. 1, three days after a rain.

It will be noted that the development after the rain was more rapid than after irrigation, notwithstanding that the water was applied artifically from time to time during the period of growth under observation, while the wetting by rain occurred but once. The fact, however, must not be lost sight of, that following the rain there is a marked rise in the relative humidity, though I regret that I did not take observations on this point at the position of the plant. Then, too, the ground got a good soaking, and it is remarkable how rapidly the soil becomes moist for a considerable depth. Undoubtedly this fact was contributory to the rapid growth of the post-pluvial foliage. In the experiment detailed above, the total growth in a few days was due wholly to the water available on the surface of the stem, and the inference is not strained, I believe, if we conclude that, normally, the first stimulus to growth in the leaves is due to the water taken up, probably, at or near the buds. In view of the very thick coating of waxy bark it seems unlikely that the water would find entrance elsewhere, though we may be wrong in this, since there are rifts through which conceivably the water might enter.

It may also be noted that the buds of the ocotillo are minute, sometimes indeed scarcely visible, and covered by, at most, a few light-brown, thin, chaffy scales. The repeated loss of leaves at the same place results in a rough area surrounding the base of the bud at which water may, we may well believe, be taken up. There is otherwise no evidence of the presence of any special adaptive structures to this end, and their absence in a very marked desert type of plant is not to be overlooked. That the absorption of water by the stem is of no very great importance, if any, in the economy of the ocotillo, may perhaps well be maintained ; while on the other hand we might argue that in regions where the rain is very scarce the very rapid production of foliage would be of so great importance that even the little water absorbed would be equally so. At any rate, the question here barely touched upon is one of a host of similar ones which need elucidation by constant study under just such special conditions as are to be found in the desert.

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CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 221

THE GENUS ALCICORNIUM OF GAUDICHAUD

By LUCIEN MARCUS UNDERWOOD

NEW YORK
1905

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 32: 587-596. 1905]

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[From the Bulletin of the Torrey Botanical Club, 32 : 587-596. 1905.]

The genus Alcicornium of Gaudichaud

Lucien Marcus Underwood

The adoption of 1753 as the initial date for botanical nomenclature in the Rochester rules of 1892, ratified by the Genoa botanical congress in the same year, reiterated by various botanical organizations down to the present year, and now almost universally accepted by botanists, settled a supplementary but more fundamental problem which had hitherto been an obstacle to the progress of a correct understanding of genera. The principle thus established is briefly stated as follows: *A genus is a group of closely related species and not a definition.* The converse view of this principle has led to untold misconceptions in regard to a proper understanding of what genera really are, particularly among the ferns. If a species has no near relations it will form a monotypic genus concerning whose nomenclatorial type there can be no question; nevertheless, in the practice of the past, generic names of this sort have often been passed along from the original monotype to species later added, until in their present acceptance they would not be recognized by their founders. Linnaeus' *Species Plantarum* contains no diagnoses of genera, and as a necessary corollary, a genus may be founded at any time by giving a generic name to a species or group of species. Such a genus is "*rite* published," to quote an expression from an author on whose restrictions this article is in part a protest. Botanical literature has frequent examples of such publications, of which I cite a single one which has recently been accepted without question:

In an "observatio" appended to the description of the genus *Bolbitis*, Schott (Gen. Fil. *pl. 14*) says: "Praeter *Bolbitin* alia duo genera: *Elaphoglossum* et *Rhipidopteris*, ab Acrostichis genuinis sunt segreganda. Prioris generis exempla sunt: E. simplex, conforme, apodum, viscosum, vestitum, etc. (Acrost. simplex, conforme etc. Auctorum); posterioris * * *." (1834.)

This is the proper starting point of the genus *Elaphoglossum*, and no one has seemed to take the gerundive construction in any other way than an intention on the part of the author to here establish a new genus. A few years earlier Gaudichaud, in the narrative of his report on the voyage of *l'Uranie* says (page 48): "On trouve de plus une fougère très-remarquable qui abonde sur les rameaux de tous les tamariniers: c'est l'*Acrostichum alcicorne*, ou du moins une espèce ou variété du genre (*Alcicornium*) qu'on ne manquera pas de faire de ces plantes dès qu'elles seront mieux examinées." We can hardly discern the distinction between this case and that of *Elaphoglossum*, and we must consider the genus *Alcicornium* as "*rite* published" by the association of a generic name with a type species; and Mr. Christensen, who includes among certain just criticisms * of my recognition of fern genera of the Old World a rejection of this genus, is surely inconsistent in taking up *Elaphoglossum* while denying validity to *Alcicornium*. It is true that in the latter case Gaudichaud withdrew his name in the same work (page 307), but there was an interval of nearly two years between the first publication and the second,† during which Desvaux published the genus *Platycerium* more formally, and Gaudichaud with the characteristic "après vous, monsieur" of French courtesy simply withdrew his genus in deference to Desvaux. It is a generally recognized principle of biological nomenclature that "a name is a name," and that a genus once published cannot be withdrawn from nomenclature even by its own author. The only reason for withdrawing a published name is the proof that it is either a synonym or a homonym. If Desvaux had not published *Platycerium* in 1827 no one would have hesitated to cite *Alcicornium* as dating from its first publication at page 48 of Freycinet's voyage in 1826. On the principle of priority of publication, therefore, we must accept the name *Alcicornium* as the proper designation for the unique genus of stag-horn ferns.‡ If we were to decide nomenclature on a principle of purely temporizing expediency and in entire disregard of principles, as advocated at the recent Vienna congress, we might argue the continuance of the name *Platycerium*, but once adopting the principle of priority of publication as a fundamental law and the date of 1753 as initial, which annuls the old conceptual idea of a genus, we are forced to adopt *Alcicornium*.

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* Christensen. On the American species of *Leptochilus* sect. Bolbitis. Bot. Tidssk. **26**: 283–300. 1904. Much of Mr. Christensen's criticism is based on a misconception of my point of view; our conceptions of the limitations of genera are wholly different. In the single case of *Belvisia* I had overlooked the synoptical publication of the genus in which the order of the species is inverted from that in its more formal publication in the text. This transfers *Belvisia* from *Acrostichum spicatum* to *A. septentrionale* (*Asplenium septentrionale* Hoffm.).

† The date of the publication of pages 1–48 of Freycinet's voyage is 1826. The date of the publication of pages 265–312, including the withdrawal of *Alcicornium*, is 1828. *Cf.* Jour. Bot. 39: 206. 1901.

‡ In raising this group to a tribal alliance (Bull. Torrey Club 30: 672) we overlooked the fact that this had already been done by the acute John Smith in his *Historia Filicum*, 122. 1875. We would now exclude from the tribe the peculiar genus *Cheiropleuria* placed in this alliance by Diels (Die nat. Pflanzenfam. 1^4: 336) as more properly representing, in its vascular system particularly, a high degree of differentiation in the tribe *Acrosticheae*.

The stag-horn ferns, which have attracted attention since the time of Plukenet, two centuries ago, by their bizarre appearance and habit of growth, are, with one exception, confined to the tropical and sub-temperate regions of the Old World. Except for Hooker's treatment in *Species Filicum* they have never been monographed, and as the recent literature relating to individual species is greatly scattered we present this preliminary revision with references to the numerous illustrations that have been published, particularly since these ferns are attracting considerable attention in cultivation at the present time. In this connection we shall attempt to elucidate the nomenclatorial tangle not only of the generic name but of the specific name of one of the commonest species, since two of the species of the genus have been more or less mixed during their entire history.*

In 1705 Plukenet (Amal. Bot. *pl. 429. f. 2*) figured a sterile African plant with the designation *Neuroplatyceros aethiopicus, nervosis foliis, cornu cervinum referentibus* (page 151).

Müller, in 1785, described *Osmunda coronaria* (= *Alcicornium coronarium*) from Siam.

Willemet was the first to describe *Acrostichum alcicorne*, in 1796 (Usteri, Ann. 6^{18}: 61), as follows:

> *Acrostichum* (*alcicorne*) frondiformibus lobatis: lobis dichotomis. N. Habitat in Madagascaria.
>
> Stadtmannus plantam siccam dabat.
>
> Fructificatio non adest in meo specimine. In altero loborum aversam partem occupabat.

In 1799 Cavanilles (Anal. Hist. Nat. 1 : 105) described *Acrostichum bifurcatum* from Port Jackson, New Holland.

In Schrader's Jour. für die Botanik (1800^2: 11. 1801) Swartz described an *Acrosticum alcicorne* with no reference whatever to

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* *Cf.* Carruthers. The Nomenclature of *Platycerium*. Jour. Bot. 38: 123–125. 1900. Mr. Carruthers gives a number of interesting points on the early history of the species, but does not begin to fathom the nomenclatorial difficulties.

Willemet but cited Plukenet's figure; he apparently mixed two species in his account in his expressions "*laciniis * * * versus apices fructiferis*" and "*foliis primordialibus reniformibus lobatis venosis.*"

In 1804 Schkuhr (Crypt. Gewächs. 1. *pl. 2*) reproduced Plukenet's figure in color, adding Willemet's citation with a ?, using the name *Acrostichum alcicorne* without adding to the knowledge of the subject.

In 1806 Palisot de Beauvois (Fl. d'Oware et de Benin. 2. *pl. 2*) described and figured *Acrostichum Stemaria* in color, collected by Commerson in Madagascar.

In 1806 Swartz (Syn. Fil. 12 and 196) jumbled most that had been previously published under the name *Acrostichum alcicorne*, citing Plukenet, Cavanilles, and Schkuhr. Among his "*Inquirendae*" (page 17) he placed the citation of *Acrostichum alcicorne* Willemet.

In 1810 Willdenow, with a modified description of his own, continued the same jumble of references (Sp. Pl. **5**: 111).

In 1827 Desvaux (Mém. Linn. Soc. **6**: 213) established the genus *Platycerium* with the following species:

P. ALCICORNE = *Acrostichum alcicorne* Sw. in part.
P. STEMMARIA = *Acrostichum Stemaria* Beauv. (*A. bifurcatum* Cav.?).
P. ANGUSTATUM = *A. alcicorne* R. Br. Prod. Fl. Nov. Holl. 145, not Sw.
P. CORONARIUM = *Osmunda coronaria* Müll. (*Acrostichum biforme* Sw.).

Presl 1836 (Tent. Pterid. 239–240) took up *Platycerium* with three species:

P. alcicorne Gaud. (*P. angustatum* Desv.).
P. biforme (*P. coronarium* Desv., *Acrostichum biforme* Sw.).
P. Stemaria (*Acrostichum Stemaria* Beauv.).

In 1841 John Smith added a fourth species (Jour. Bot. **3**: 402) from the Philippines as *Platycerium grande* ("*Acrostichum grande* A. Cunn."), which remained a *nomen nudum* until it was described in 1845 as *Nevroplatyceros grandis* Fée, Mém. Foug. **2**: 103, and in 1852 * as *Platycerium grande* Presl, Epim. Bot. 154.

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* [According to J. Müller (Muell.-Arg.) in De Candolle's *Prodromus* (15^2: 258. 1862), Presl's *Epimeliae Botanicae*, although bearing the title-page date 1849, was not published until 1852; and as negative evidence, in favor of Müller's assertion, may

In 1845 Fée (Mém. Foug. **2**: 102–104) took up the genus *Nevroplatyceros* from Plukenet and recognized four species, viz.:

N. alcicornis, *N. aethiopicus* Pluk. (*Acrostichum Stemaria* Beauv.), *N. grandis* and *N. biformis*. The first three were placed in the § *Platyceria* and the last named in the § *Scutigera*. A fine plate (*pl. 64*) was given of the second species.

In 1864 Hooker (Sp. Fil. **5**: 282–285) again recognized *Platycerium* with species as follows:

1. *P. alcicorne* Desv.
2. *P. aethiopicum* Hook.
3. *P. grande* J. Sm.
4. *P. Wallichii* Hook.
5. *P. biforme* Bl.

In this somewhat tedious recital we can see from our present viewpoint that during the first half of the last century there were two somewhat common species, the one from Australia with narrow leaves which are usually twice forked and bear the sporangial surfaces on the distal lobes, the other with a broader leaf and usually shorter lobes, bearing the sporangial surface at the extremity of the broadened surface between the lobes. The first, which is the *Platycerium alcicorne* of recent authors, was first described by Cavanilles as *Acrostichum bifurcatum* (type locality, Port Jackson, Australia) and again by Desvaux as *Platycerium angustatum*. Presl recognized this as a distinct species but was unfortunate in the selection of his name, although he specifies that it was the *P. alcicorne* of Gaudichaud and not of previous authors. The second species is from Madagascar and other parts of Africa, where it is the more common species, and was probably the original *Acrostichum alcicorne* Willem. (type locality, Madagascar), and was certainly the *Acrostichum Stemaria* of Beauvois. It is more than likely that a young sterile and possibly abnormal leaf of this species served for the figure of Plukenet which was copied by Schkuhr a hundred years later.

It is, therefore, evident that the name *alcicorne*, which Swartz and his contemporaries used to include both plants, and which

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be noted the fact that Presl's work was reviewed by Schlechtendahl as a novelty in the Botanische Zeitung, in September 1852 (**10**: 656, 657). Internal evidence that the final touches were not given to Presl's manuscript until after the close of the year printed on his title-page, is to be found in two direct citations, on page 261, of species published by Kunze in 1850 (Bot. Zeit. **8**: 57, 58. 25 Ja 1850). Finally, an inspection of the original paper cover of the *Epimeliae* shows that it is dated (on last page) "Pragae, 1851." ——J. H. B., Ed.]

later authors with more or less precision, commencing with Gaudichaud and Presl, have used for the Australian species, does not belong with it, and that only with doubt can *Acrostichum alcicorne* Willem., in the absence of its type, be referred to any species known to-day. The overwhelming probability, however, points to it as being the same as *Acrostichum Stemaria* Beauvois.

With these modifications of existing nomenclature we proceed to an enumeration of the species, of which there appear to be thirteen known at the present time; of these eight species are in cultivation at the Royal Botanical Garden at Kew, and seven species at the New York Botanical Garden. Three species we have seen only in herbarium collections, and there is only one (*A. sumbawense*) which we have not seen in some form.

Synopsis of the species of Alcicornium*

- Sporophyls broad, with no narrow strap-like divisions.
    - Sporophyls rounded at the apex, with entire or repand margins; sporangial area oval; basal leaves erect. 2. *A. angolense.*
    - Sporophyls more or less lobed at the apex.
        - Apex with two rounded lobes; margins otherwise entire; sporangial areas reniform. 5. *A. Ellisii.*
        - Apex with irregular margins showing manifest tendency to fork; sporangial areas irregular in shape following the outline of the leaf; basal leaves thick, with deep irregular pits when dry. 8. *A. madagascariense.*
- Sporophyls with narrow strap-like lobes, in shape resembling a stag's horn.
    - Sporangial areas on a stalked scutiform disc. 4. *A. coronarium.*
    - Sporangial areas on the surface of the sporophyl.
        - Sporangial areas at or below the forks and not on the strap-like lobes of the leaf.

---

* We add here the original description of the only species not seen:

" *P. sumbawense* n. sp. Christ.

Inter P. alcicorne Desv. et P. Wallichii Hook. habitu intermedium, sed omnium angustissimum. Frondibus fertilibus pallidis binis, ternis sive quinis, ligulatis loriformibus, ad basin sensim attenuatis, 65 cm longis, parte latissima 3 cm latis, sulcato-nervosis, adpresse floccosis, media circiter longitudine dichotomo-divisis, atque iterum bis dichotomis, segmentis ultimis furcatis (laciniis ultimis usque ad 20 pro fronde) lanceolato-triangularibus rostratis, involutis, 7 ad 6 cm longis obtusiusculis, omnibus soriferis, soris faciem inferiorem usque ad basin laciniarum omnino tegentibus, immature pube densa albida obtectis, mature rufis partim ista pube tectis. Frondibus sterilibus, politis nitidis scariosis fragilibus spongiosis ochraceo-fulvis reniformi-rotundatis 15 ad 30 cm diametro, margine laciniatis laciniis profundis furcatis. Nervis conspicuis areolas elongatas angulosas formantibus, nervulis aliquot lateralibus liberis inclusis.

Differt a P. alcicorni lamina magis decomposita, angusta, segmentis multo minoribus, rostratis, numerosis. Differt a P. Wallichii statura multo minore, omnibus partibus angustioribus, et soris terminalibus nec in sinu ramorum positis." Warburg, Monsunia 1: 64. 1900.

  - Sporangial area on an enlarged basal portion of the sporophyl. 6. *A. grande.*
  - Sporangial area at the sinus of the second fork of the sporophyl.
    - Basal leaves laciniate into strap-shaped lobes; sporangial areas oval, on a modified portion of the sporophyl. 12. *A. Wallichii.*
    - Basal leaves undulate or entire at the margins; sporangial area triangular, on the unmodified surface of the sporophyl. 9. *A. Stemaria.*
- Sporangial areas on the narrow strap-like lobes of the sporophyl, only exceptionally extending below the sinus.
  - Sporophyls rigid, erect in growth, gradually widening upwards and then forming several lobes or divisions.
    - Bright-green both sides; sporangia-bearing divisions broad (5–8 cm.). 7. *A. Hillii.*
    - White both sides but becoming greenish above from the deciduous stellate scales; sporangia-bearing divisions narrow (2.5 cm. or less wide). 11. *A. Veitchii.*
  - Sporophyls lax, pendent in growth.
    - Sporangial areas on or near the apices of the lobes. (Species of the Old World).
      - Basal leaves erect and foliaceous; sporophyls many times forked. 13. *A. Willinckii.*
      - Basal leaves remaining flat and disc-like; leaves 2–3 forked. 3. *A. bifurcatum.*
    - Sporangial areas medial on the sporophyls. (Andine species.) 1. *A. andinum.*

1. **Alcicornium andinum** (Baker)

Platycerium andinum Baker, Ann. Bot. **5**: 496. 1891; New Ferns 113. 1892. (Type from Peru, *Spruce 4729.*)

RANGE: Mountains of Peru and Bolivia, first collected by Spruce. The only American species known; strangely confused by Hooker with *A. bifurcatum.*

2. **Alcicornium angolense** (Welw.)

Platycerium angolense Welw.; Hooker & Baker, Syn. Fil. 425. 1868. (Type from Angola, *Welwitsch.*)

Platycerium Elephantotis Schweinf. Bot. Zeitung **29**: 361. *fig.* 1878. (Type from central Africa.)

RANGE: Tropical Africa.

ICON.: Gard. Chron. III. **23**: 155. *f. 62.* 1898; Rev. Hort. Belge **28**: 85. *pl.* 1902; Schweinfurth *loc. cit.*

Schweinfurth's wood cut illustration is very misleading and does not at all compare with his specimens at Kew, which differ in no particular from *A. angolense.*

3. **Alcicornium bifurcatum** (Cav.)

Acrostichum bifurcatum Cav. Anal. Hist. Nat. **1**: 105. 1799. (Type from Port Jackson, Australia.)

Platycerium angustatum Desv. Mem. Linn. Soc. Paris **6**: 213. 1827. (Type from Australia.)

Acrostichum alcicorne R. Br. and *in parte minore* of Swartz and Willdenow. Not *A. alcicorne* Willem.

Platycerium alcicorne of Gaudichaud and Presl.

RANGE: Australia, Lord Howe Island, New Caledonia; possibly extending to Africa, but exact data are wanting.

ICON.: Turpin, Dict. Hist. Nat. (Atlas); Bot. Register **3**: *pl. 262, 263.*

4. **Alcicornium coronarium** (Müller)

Osmunda coronaria Müller, Naturforscher **21**: 107. *pl. 3.* 1785. (Type from Siam.)

Acrostichum biforme Sw. Jour. für die Bot. (Schrader) **1800²**: 11. 1801.

Platycerium coronarium Desv. Mém. Linn. Soc. Paris **6**: 213. 1827.

Platycerium biforme Blume, Fl. Jav. Fil. 44. *pl. 18.* 1829.

Nevroplatyceros biformis Fée, Mém. Foug. **2**: 104. 1844–5.

RANGE: East Indies from Siam to Penang, Singapore, Sumatra, Borneo and the Philippines.

ICON.: Müller *loc. cit.*; Blume *loc. cit.*; Beddome, Ferns of Brit. India *pl. 224.*

5. **Alcicornium Ellisii** (Baker)

Platycerium Ellisii Baker, Jour. Linn. Soc. **15**: 421. 1876. (Type from Madagascar, *Ellis.*)

RANGE: Known only from central Madagascar.

ICON.: Baker, Hook. Ic. Pl. **17**: *pl. 1695.*

6. **Alcicornium grande** (J. Sm.)

Platycerium grande J. Sm. Jour. Bot. (Hooker) **3**: 402.

1841 (*nomen nudum*); Presl, Epim. Bot. 154. 1852.*
(Type from the Philippines.)

Nevroplatyceros grandis Fée, Mém. Foug. **2**: 103. 1845.

RANGE: East Indies from Singapore to North Borneo and the Philippines; also Moreton Bay, Australia.

ICON.: Hooker, Gen. Fil. *pl. 80 B* (as *Pl. biforme*); Hooker, Fil. Exot. *pl. 86;* Beddome, Ferns of Brit. India *pl. 326;* Gard. Chron. III. **28**: 433. *f. 134.*

7. **Alcicornium Hillii** (Moore)

Platycerium Hillii Moore, Gard. Chron. II. **10**: 429. *f. 74–75.* 1878. (Type from Queensland, *Hill.*)

RANGE: Known only from Queensland, Australia.

ICON.: Moore *loc. cit.*

8. **Alcicornium madagascariense** (Baker)

Platycerium madagascariense Baker, Jour. Linn. Soc. **15**: 421. 1876. (Type from Madagascar, *Pool.*)

RANGE: Known only from Madagascar, the type locality.

9. **Alcicornium Stemaria** (Beauv.)

Neuroplatyceros aethiopicus, nervosis foliis, cornu cervinum referentibus. Pluk. Amal. Bot. 151. *pl. 429. f. 2.* 1705.

? *Acrostichum alcicorne* Willemet, Usteri Ann. 6^{18}: 61. 1796. (Type from Madagascar, *Stadtmann.*)

Acrostichum Stemaria Palisot de Beauvois, Fl. d'Oware et de Benin 2. *pl. 2.* 1804. (Type from Madagascar, *Commerson.*)

Platycerium Stemmaria Desv. Mém. Linn. Soc. Paris **6**: 213. 1827.

Nevroplatyceros aethiopicus Fée, Mém. Foug. **2**: 103. *pl. 64.* 1845.

Platycerium aethiopicum Hook. Garden Ferns *pl. 9.* 1861.

Acrostichum alcicorne of Swartz and Willdenow *pro parte majore.*

RANGE: Tropical Africa from Madagascar to Fernando Po, and north to Sierra Leone.

ICON.: Plukenet *loc. cit.;* Beauvois *loc. cit.;* Fée *loc. cit.;* Hooker, Garden Ferns *pl. 9;* J. Sm. Hist. Fil. *pl. 5.*

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* See footnote on page 590.

10. **Alcicornium sumbawense** (Christ)

Platycerium sumbawense Christ, in Warburg, Monsunia **1**: 64. 1900. (Type from Sumbawa, *Warburg 17266.*)

RANGE: Known only from its type.

This species is possibly not distinct from *A. Willinckii*, so far as one can judge by the description (*q. v.*, page 592, note).

11. **Alcicornium Veitchii** sp. nov.

Platycerium Veitchii Gard. Chron. III. **19**: 652. 1896; Jour. Roy. Hort. Soc. **20**: lxxxiii. 1896 (*nomen nudum*).

Basal leaves appressed, soon becoming brownish; spore-bearing leaves cespitose (up to 11 in the cluster), 60 cm. or more long, narrow at the base, tapering gradually to a width of 5–10 cm. or more, then dividing into 6–8 narrow pseudopalmate lobes, 10–20 cm. long by 2–2.5 cm. wide, all becoming more or less sporangiferous in irregular areas; upper surface grayish-scurfy from the quantities of stellate hairs which soon become loosened, finally smoothish in irregular areas from these hairs becoming deciduous; under surface clear white from the abundant, crowded, silvery, star-like matted hairs.

Imported from Adelaide, Australia with other plants by Messrs. Veitch, the horticulturists for whom the species is named, and by them publicly exhibited in 1896. Described from living plants in hort. Kew, September, 1905.

A very distinct species of rigid habit quite in contrast with the other Australian members of the genus.

12. **Alcicornium Wallichii** (Hook.)

Platycerium Wallichii Hook. Gard. Chron. **1858**: 764. 1858.

RANGE: India (type from the banks of the Irawaddy, *Wallich*).

ICON.: Hooker, Fil. Exot. *pl. 97;* Beddome, Ferns of British India *pl. 108.*

13. **Alcicornium Willinckii** (Moore)

Platycerium Willinckii Moore, Gard. Chron. II. **3**: 302. *f. 56.* 1875.

RANGE: Java (type from Java, whence it was introduced to cultivation by Willinck about 1873).

ICON.: Moore *loc. cit.;* Garden **10**: 383. *f.* 1876.

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COLUMBIA UNIVERSITY,
NEW YORK CITY.

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CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 222

THE GENUS STENOCHLAENA

By LUCIEN MARCUS UNDERWOOD

NEW YORK
1906

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 33: 35–50. 1906]

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 33: 35–50. 1906.]

The genus Stenochlaena

LUCIEN MARCUS UNDERWOOD

In no portion of *Synopsis Filicum* does the lack of coördination of the work of other authors manifest itself more strikingly than at page 412 under *Acrostichum sorbifolium*, where the elaborate work of Fée, which had appeared twenty-two years previously, is made to pass for naught, and his seventeen species of *Lomariopsis* are reduced to synonymy. While the elder Hooker was writing the *Species Filicum*, of which the *Synopsis* is a revised and abbreviated digest, Kunze and, later, Mettenius, were describing ferns independently at Leipzig, as was also Presl at Prague, and Fée at Strasburg. The work at each of these centers appears to have gone on in practical independence and without much comparison or coördination. Such species as happened to come to Kew appear to have been reviewed, and the others were often reduced to synonymy with no specimen at hand. Some were never mentioned. The visitation of other centers seems rarely if ever to have been practiced. Presl had no successor to his studies and his still unmounted fern collection exists to-day at Prague, apparently never visited by modern European fern students or monographers. At Berlin, Kuhn was the lineal successor of Mettenius, as Fournier at Paris was the successor of Fée. At Berlin, in addition to the collection of Willdenow, most of the types of Kaulfuss, Kunze, Klotzsch, Mettenius and Kuhn may be seen, and at Paris most of those of Lamarck, Bory, Desvaux, Fée and Fournier are at the museum of the Jardin des Plantes, but neither Hooker nor his successors at Kew consulted them, and to this present year of grace, continental European fern students have never taken the trouble to coördinate them with the Kew collection, but have continued to work on in the same old independent ways.

In attempting to elucidate the American species of *Stenochlaena*, the fact that Hooker had attributed one of our West Indian species to nearly all parts of the tropical world * made it necessary to review the entire genus. During the past summer, while visiting the collections at Vienna, Prague, Berlin, Paris and Kew, the specimens representing this genus were examined comparatively and the following revision is the result of this first synoptical study of a genus based on the materials of all the great fern collections ot the world. How different the result appears from that based on the study of the material at a single center may be seen by comparing the present revision with the treatment of the same group in *Synopsis Filicum*, where most of the species of other authors are ruthlessly reduced to synonymy under *Acrostichum sorbifolium*, originally from the West Indies. To the twenty-three Old World species here recognized should be added ten or more which represent the American development of the genus and which will be given a separate treatment. Five species appear in *Synopsis Filicum;* of these three reappear without change; three are here described as new, and the remainder represent species either unknown to the authors of *Synopsis Filicum* or unfortunately reduced to synonymy by them.

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* "West Indies to Peru and South Brazil; Fiji, Samoa, New Caledonia, Philippines, Malaccas, Cochin China, Seychelles, Mascaren Isles, Angola, Guinea Coast." — Syn. Fil. 412.

The genus *Stenochlaena* forms a rather natural group of non-indusiate ferns whose nearest relatives are to be found in the dimorphous species of *Stegania* R.Br. (*Lomaria* Willd.) as suggested in the name (*Lomariopsis*) given to one section of the genus when monographed by Fée sixty years ago. In fact the species with narrow pinnae in the sporophyls have often been described in the genus *Lomaria*, as those with wider pinnae were supposed to have a corresponding relation to *Acrostichum*. At least four genera have been established from among the species, the name *Stenochlaena* being the oldest for any member of the group. In recent papers Dr. Christ still maintains the genera *Lomariopsis* and *Stenochlaena* as distinct, but this seems less rational than to unite them as sections of one genus. It is true that we have two types of venation represented in the group: the first with the lateral veins springing from the midrib, and the second with accessory veins parallel and adjacent to the midrib with the lateral veins springing from them. Pinnae jointed to the rachis occur in species with both types of venation. The species with the second type have spiny leaves, while those with the first type have a normally cartilaginous margin to the pinnae. With these slight differences, it seems better, therefore, to recognize only a single genus with four fairly marked sections which may be distinguished as follows:

Synopsis of the sections of Stenochlaena

Lateral veins springing from a vein lying parallel to the midrib and occasionally connecting with it; margins of the pinnae spiny.
  Sporophyls simply pinnate. § **Eustenochlaena.**
  Sporophyls normally bipinnate. § **Cafraria** Presl.
Lateral veins springing direct from the midrib; pinnae not spiny.
  Climbing stems spiny, not scaly, naked; leaves trimorphous. § **Teratophyllum** Mett.
  Climbing stems not spiny, usually more or less densely scaly. § **Lomariopsis** Fée.

The species of the first three sections are all confined to the tropics of the Old World. Those of the section *Lomariopsis* are divided between the tropics of the Old and New worlds, approximately in the ratio of three to two.

§ 1. EUSTENOCHLAENA

The genus *Stenochlaena* was founded by John Smith in 1841 and was based on *Acrostichum scandens* * as a type. The species closely allied to this, then, must constitute the section *Eustenochlaena*, notwithstanding the fact that there has been a different use for the term.† There are three species of this section, one of which has a wide range and presents considerable variation from its various stations. The other two species have quite a limited range. They may be easily separated by the following synopsis:

Pinnae of the sporophyls narrow, 3 mm. wide. 3. *S. palustris.*
Pinnae of the sporophyls wider, 5–10 mm. wide.
  Pinnae 3.5–4 cm. wide, rounded-obtuse at the base; pinnae of the sporophyls narrow, 5 mm. wide. 2. *S. Milnei.*
  Pinnae 3 cm. wide, truncate at the base; pinnae of the sporophyls wider, 10 mm. wide. 1. *S. laurifolia.*

1. STENOCHLAENA LAURIFOLIA Presl, Epim. Bot. 164. 1851 (type from Luzon, *Cuming 226*).

Acrostichum laurifolium Hook. Sp. Fil. 5: 250. 1864.—Syn. Fil. 412.

RANGE: Philippine Islands.

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* SMITH (Jour. Bot. Hook. 3: 401. 1841) wrongly attributes this species to Linnaeus. His context, however, makes clear the species intended. Later he included members of other sections in the genus (Jour. Bot. Hook. 4: 149. 1841).

† DIELS, Die natürlichen Pflanzenfamilien 1^4: 251. 1899; where the term *Eustenochlaena* is used to include also species of *Lomariopsis* Fée.

2. **Stenochlaena Milnei** sp. nov.

Creeping stems unknown; leaves pinnate; pinnae 6–7- (or more) jugate, rigid, coriaceous, rounded-obtuse at base, nearly sessile; 20 cm. or more long, 3–3.5 cm. wide, the margins thickly beset with small spines, the apex long-acuminate; veins close, 17–18 spaces to the centimeter, simple or occasionally forked at or near the base; surfaces smooth and shining; sporophyls pinnate; the pinnae about 9-jugate, 25 cm. or more long, 5 mm. wide, tapering at the apex, inclined to be revolute when dry; rachises pallid, smooth, rather stout.

SOLOMON GROUP: *Milne 518* (type), K; *ibid. 590*, K.

NEW GUINEA: *Honkmann*, K (fragment); *Armit*, K (sporophyl only).

ADMIRALTY ISLANDS: *Moseley* (Challenger Exped.), K.

S. Milnei is represented at Kew by fragmentary materials which do not show the stem characters; it is, however, sufficiently differentiated from the variable *S. palustris*, and especially from *S. laurifolia*, under which Hooker cites the type, to justify separation even on present materials. Specimens have been seen only at Kew.

3. STENOCHLAENA PALUSTRIS (Burm.) Beddome, Suppl. Ferns India 26. 1876.

Polpypodium palustre Burm. Fl. Ind. 234. 1768. (Type from Ceylon.)

Onoclea scandens Sw. Syn. Fil. 112, 309. 1806. (Change of Burmann's specific name without warrant.)*

Lomaria scandens Willd. Sp. Pl. **5**: 293. 1810.

Lomaria ? juglandifolia Presl, Rel. Haenk. **1**: 52. 1825. (Type from the Philippines, *Haenke.*) †

Lomaria ? Haenkeana Presl, Rel. Haenk. **1**: 53. 1825. (Type from Sorzogon, Luzon, *Haenke.*)

Stenochlaena scandens J. Sm. Jour. Bot. Hook. **3**: 401. 1841.

Stenochlaena Blumeana Presl, Epim. Bot. 163. 1851. (Type from Tranquebar, *Bottler.*)

Stenochlaena Haenkeana Presl, Epim. Bot. 165. 1851.

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* Swartz, moreover, has his references to Burmann sadly mixed and attributes the species to Linnaeus who apparently never mentioned it. John Smith copied Swartz' error in establishing the genus *Stenochlaena*.

† Like many other plants in this work Presl reported this originally from Mexico but corrected it in his herbarium and in his later writings.

Acrostichum scandens Hook. Sp. Fil. **5**: 249. 1864.—Syn. Fil. 412. 1868.

Lomariopsis palustris Mett. Ann. Mus. Lug.-Bat. **4**: 294. 1869.

ICON.: Rheede, Hort. Malab. **12**: *pl. 35.* 1703; Burmann, Thes. Zeyl. *pl. 46.* 1737; Rumphius, Herb. Amboin. **6**: *pl. 31.* 1750; Schkuhr, Crypt. Gewächse *pl. 106, 107;* Hooker & Bauer, Gen. Fil. *pl. 105 B;* Fée, Mém. Foug. **5**: *pl. 5 A. f. 2;* Beddome, Ferns Southern India *pl. 201.*

RANGE: India from Punjab?, Sikkim and Ceylon, to Malacca, Java, Sumatra, Borneo, the Philippines, to Queensland, Fiji, Samoa, and Tonga Islands.

§ 2. CAFRARIA Presl.

This group was set apart by Presl as a section in 1851.* It agrees with *Eustenochlaena* in venation and in the marginal spines of the pinnae, but differs in the bipinnate sporophyl, a character wholly insufficient to separate it as a genus. Fée founded the genus *Lomariobotrys* on the same group in 1852.

A single species:

4. **Stenochlaena tenuifolia** (Desv.)

Lomaria tenuifolia Desv. Berl. Mag. **5**: 326. 1811. (Type from Madagascar.)

Lomaria Meyeriana Kunze, Linnaea **10**: 509. 1836. (Type from Natal?, "inter Omtendo et Omsamculo," *Drege.*)

Stenochlaena Meyeriana Presl, Epim. Bot. 166. 1851.

Lomariobotrys Meyeriana Fée, Mém. Foug. **5**: 46. *pl. 5A.* 1852.

Lomariobotrys tenuifolia Fée, Mém. Foug. **5**: 46. 1852.

Acrostichum Meyerianum Hook. Garden Ferns *pl. 16.* 1862.—Sp. Fil. **5**: 250. 1864.

Acrostichum tenuifolium Baker, Syn. Fil. 412. 1868.

ICON.: Hooker, *loc. cit.;* Fée, *loc. cit.*

RANGE: Africa from the Cape of Good Hope and Natal to Nossibé, Madagascar, Mauritius, and the Comoro Islands.

There are specimens in the Kew herbarium in which there are some simply pinnate sporophyls as well as the normally bipinnate ones, said to have grown on the same plant.

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* In publishing *Lomariobotrys*, Fée adds the date 1851, citing *Cafraria* Presl, Epim. Bot. 166. This seems to fix the date of the Epim. Bot. as 1851 rather than 1852 (cf. Bull. Torrey Club **32**: 590, *note*). This also enables us to cite 1852 instead of "1850–52" for Fée's fifth Memoir.

§ 3. TERATOPHYLLUM Mett. (in part).

In 1869 Mettenius established the genus *Teratophyllum* based on *T. aculeatum* (*Lomaria aculeata* Bl.) and *T. articulatum* (*Polybotrya articulata* J. Sm.). The latter species forms the type of the genus *Arthrobotrya* J. Sm., and appears to be a valid genus. In this group the rootstock is spiny and naked, the veins are free, the pinnae are articulated to the rachis, and the leaves are trimorphous. In addition to the ordinary foliage leaves which are simply pinnate like those of the other sections of the genus, there are accessory bipinnate or even tripinnate leaves which often lie more closely appressed to the surface over which the plant climbs. A good illustration of this feature may be seen in Karsten, Ann. Bot. Jard. Buitenzorg **12**: *pl. 14*, copied in Velenovsky's Vergleichende Morphologie der Pflanzen 200, *f. 128*. 1905. Such dissected leaves are not unknown in other ferns, occurring even in some of the *Cyatheaceae*.

There are three species known at present, all confined to the East Indian region both continental and insular. They may be distinguished as follows:

Foliage green; pinnae 1.5–2.5 cm. wide, nearly sessile. 5. *S aculeata.*
Foliage pink or violet when dry; pinnae 1 cm. or less wide.
  Pinnae obtuse or truncate at the base, short-stalked; sporophylary pinnae as long as the sterile. 6. *S. gracilis.*
  Pinnae cuneate at the base, long-stalked; sporophylary pinnae twice the length of the sterile. 7. *S. Williamsii.*

Besides the above there are indications of a fourth species, from Perak, with green foliage, the pinnae stalked (1–1.5 cm.), subcoriaceous, and 2.5–3 cm. wide. Specimens exist at Kew.

5. STENOCHLAENA ACULEATA (Blume) Kunze, Bot. Zeitung 6: 142. 1848.

Lomaria aculeata Blume, Enum. Pl. Jav. 205. 1828. (Type from Java.)

Lomariopsis spinescens Fée, Mém. Foug. **2**: 71. *pl. 33. f. 1.* 1844–5. (Based on the above with an unwarranted change of of specific name.)

Lomariopsis ludens Fée, Mém. Foug. **2**: 70. *p. 30.* 1844–5. (Type from Singapore, *Gaudichaud.*)

Davallia achillaefolia Wall. Cat. n. 248; Hooker, Sp. Fil. **1**: 195. *pl. 56 D.* 1846. (Type from Penang, *Wallich.*)

Teratophyllum aculeatum Mett. Ann. Mus. Bot. Lug.-Bat. **4**: 296. 1869.

Acrostichum aculeatum Racib. Pter. Fl. Buitenzorg 53. 1898.

ICON.: Fée, *loc. cit.;* Hooker, *loc. cit.;* Karsten, Ann. Jard. Bot. Buitenzorg **12**: *pl. 14.* 1893.

RANGE: Perak, Tenasserim, Java, Borneo, and the Philippines. Usually appears in herbaria in a sterile condition. A var. *inermis* Mett., without spines on the rootstock, has also been described (Mett. *loc. cit.* 297).

6. STENOCHLAENA GRACILIS (Blume) Kunze, Bot. Zeitung **6**: 142. 1848.

Lomaria gracilis Blume, Enum. Pl. Jav. 205. 1828.

Acrostichum gracile Racib. Pter. Fl. Buitenzorg 53. 1898.

RANGE: Java.

7. **Stenochlaena Williamsii** sp. nov.

Stems pink, 3–8 mm. thick, widely creeping, densely rooting below, spiny above; foliage leaves scattered, about 6 cm. apart, up to 60 cm. long, the stalks pink with a slight tinge of brown, slightly fibrillose, with a slight ridge and groove along the upper side, pinnate; the pinnae deciduous, stalked (5 mm. or more), lanceolate, 12–15 cm. long, 1.5 cm. wide, cuneate tapering at the base, acuminate at the apex, the margin slightly repand or entire, the surfaces smooth, the midrib prominent, reddish, with occasional fibrils; veins distinct, close (about 15 spaces to 1 cm.), simple or forked; sporophyls pinnate, the pinnae deciduous, long-stalked (8–10 mm.), 25–28 cm. long, 1.5–2 mm. wide, with conspicuous midrib; secondary foliage leaves 1–2 cm. long (or larger in young plants), bipinnatifid, membranous, in growth appressed to the substratum.

PHILIPPINES: Lamao River, Mt. Mariveles, Prov. Bataan, Central Luzon, alt. 120 meters, *Williams 684.* Type in the herbarium of the New York Botanical Garden.

Growing on trees. "Young plants with finely dissected leaves." Unfortunately few of the secondary foliage leaves were secured, so that their exact relation to the others is not clear in the type specimen. The species differs from *S. aculeata* in its narrow pink pinnae, the color appearing in every part of the plant when dry. From *S. gracilis* it differs in its cuneate acute bases of the pinnae and the elongate pinnae of the sporophyls.

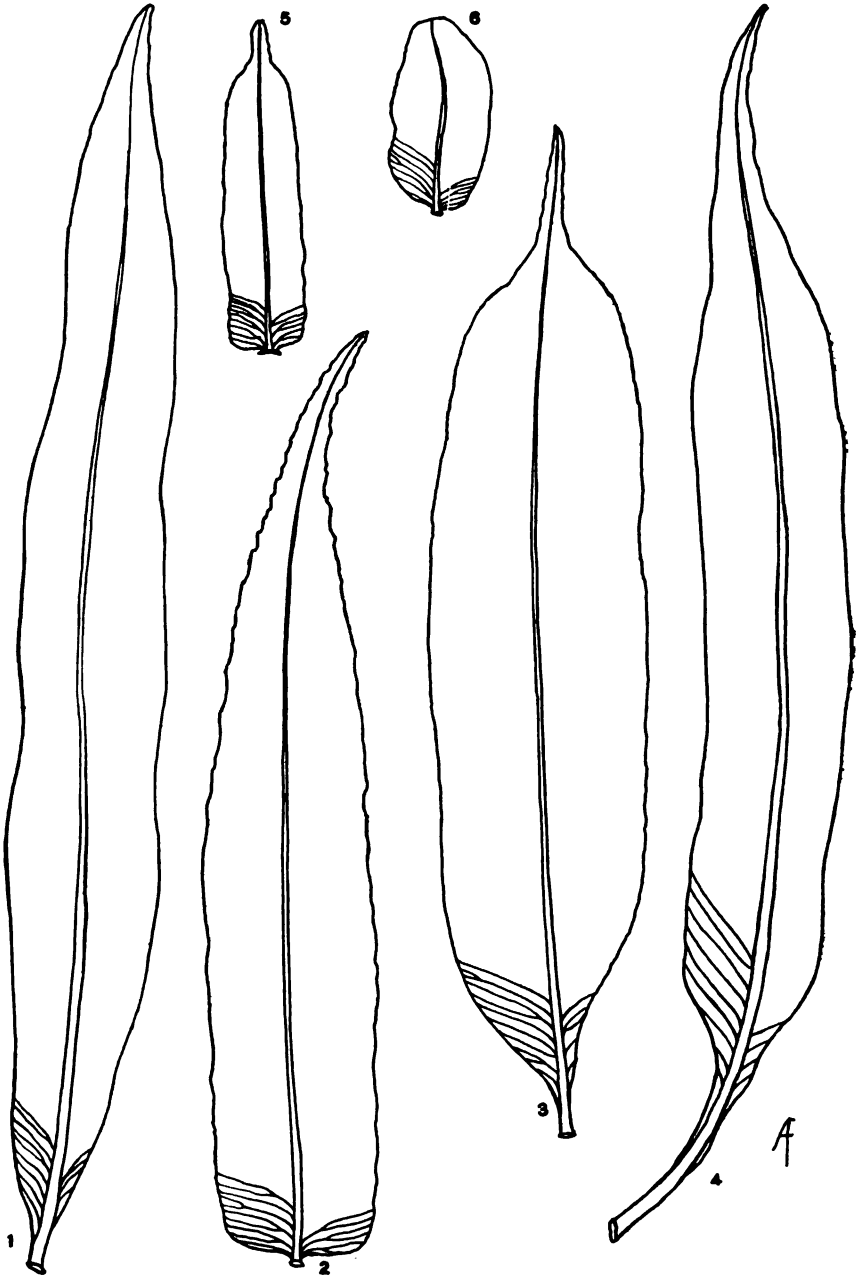
§ 4. LOMARIOPSIS Fée

The numerous members of this section, which were so summarily crowded into one species by Hooker, form a natural group in which free veins rising directly from the midribs, scaly climbing rootstocks rarely if ever armed with prickles, and pinnae continuous with the rachis form the most obvious characters. The species are widely distributed and have thereby become notably diverse in the various parts of the earth where they now appear. As a rule the individual species have very clearly marked characters combined with a narrow geographic range. It is therefore somewhat simpler to treat of the great continental regions separately. The American species will form the subject of a separate paper. The accompanying figures of normal lateral pinnae, drawn natural size, will show something of the diversity of leaf-form in the genus in the Old World.

1. THE SPECIES OF AFRICA AND ITS ISLANDS

Willemet (1796) was the first to describe a species of this group from Africa under the name of *Osmunda pollicina*. Later species have been separated by Bory, Fée, Kunze, Mettenius, Kuhn, and Baker, who have each added a single species to the flora, and an eighth is here published as new. The species range from Sierra Leone to Fernando Po on the west coast and across the continent to the islands of Mauritius and Madagascar. Their differential characters will become apparent in the following synopsis:

- Pinnae truncate at base.
    - Pinnae 5 cm. or less long, those of the lowest third of the leaf gradually decreasing to mere auricles. 11. *S. decrescens.*
    - Pinnae 15 cm. long, only the lowest 2–3 pairs slightly smaller. 16. *S. Mannii.*
- Pinnae cuneate or rounded-obtuse at the base, never truncate.
    - Lateral pinnae under 7 cm. long, rounded-obtuse at the base.
        - Pinnae pointed at the apex, 7 by 2 cm.; pinnae of the sporophyls 7.5 cm. long by 5 mm. wide. 20. *S. pollicina.*
        - Pinnae rounded at the apex, suboval.
            - Pinnae of the sporophyls 10–12 mm. long by 2–3 mm. wide, obtuse at the apices. 9. *S. buxifolia.*
            - Pinnae of the sporophyls 3 cm. long by 4–5 mm. wide, pointed at the apices. 15. *S. lomarioides.*
    - Lateral pinnae 10–15 cm. or more long, cuneate at the base.



Some of the species confused under *Stenochlaena sorbifolia*. Normal lateral pinnae, natural size. 1. *S. Pervillei*. 2. *S. Mannii*. 3. *S. guineensis*. 4. *S. Brackenridgei*. 5. *S. decrescens*. 6. *S. lomarioides*.

Pinnae broadly elliptic, 3–3.5 cm. wide, abruptly narrowed to an acuminate apex. 12. *S. guineensis.*

Pinnae lanceolate, scarcely over 2 cm. wide, tapering to an acuminate apex.

  Pinnae of the sporophyls short-stalked, 2 mm. or less wide. 19. *S. Pervillei.*

  Pinnae of the sporophyls long-stalked, 4–6 mm. wide. 23. *S. variabilis.*

Species inquirendae

1. Specimens from Namuli, Makua country, East Tropical Africa, collected by *Last* (Herb. Kew.) have only sterile leaves, 9–10-jugate, but these do not agree with those of any known species. More information is necessary before locating a ninth species from Africa.

2. *Polypodium* (?) *binerve* Hook. Sp. Fil. 4: 176. *pl. 273B.* 1862, is placed by Mr. Baker as "one of the abnormal conditions of *Acrostichum sorbifolium*" (Syn. Fil. 323). It may represent a good species when its sporophyls become known. It has of course no relation to *Polypodium* other than that it is a fern, and none to *Stenochlaena sorbifolia*, but is either a distinct species or less likely a juvenile state of some one already known.

2. THE SPECIES OF THE EAST INDIAN AND AUSTRALIAN REGIONS AND OF THE PACIFIC ISLANDS

Of the eight species belonging to this region, three were described in Fée's original monograph in 1844, two were described by Carruthers in *Flora Vitiensis* and appear entirely to have escaped the notice of the Kew botanists, and one each was added by Presl, Brackenridge, and Mettenius. Most of the species are very clearly marked and not one of them approaches *S. sorbifolia*, with which all of them have been confused. The following synopsis will differentiate the species:

Pinnae narrow, 1.5 cm. or less wide.

  Pinnae serrulate; veins stopping short of the margin; pinnae of the sporophyls 1.5–2 mm. wide. 13. *S. Hügelii.*

  Pinnae entire or barely repand; veins running into a cartilaginous margin; pinnae of the sporophyls 4–5 mm. wide. 14. *S. leptocarpa.*

Pinnae wider, 2–5 cm.

  Pinnae of the sporophyls 2 mm. or less wide. 8. *S. Brackenridgei.*

  Pinnae of the sporophyls wider, 4–8 mm. wide.

    Pinnae of the sporophyls 8–15 cm. long, short-stalked.

      Foliar pinnae 2 cm. wide, tapering at the apex. 17. *S. Novae-Caledoniae.*

Foliar pinnae 3.5–5 cm. wide, abruptly acuminate at the apex.
10. *S. cochinchinensis.*
Pinnae of the sporophyls 20–30 cm. long, long-stalked (2 cm.).
Pinnae of the sporophyls gradually tapering at the apex.
22. *S. Smithii.*
Pinnae of the sporophyls abruptly acuminate at the apex.
Pinnae narrow, about 2 cm. wide. 18. *S. oleandrifolia.*
Pinnae wider, 3–3.5 cm. wide, few-jugate.
21. *S. Seemannii.*

The last two species are quite near to each other in form and general appearance and may represent only two phases of the same species. Since the meager materials represented in herbaria are insufficient, it is better to keep them apart, as they have already been established, awaiting further collection in the South seas. With the strong possibility of distinctness, this is a more rational proceeding than to unite them. This is a far different proposition from separating doubtful things in the event of a possibility of specific distinctness. The geographic range of the two species is practically the same, which further decreases the probability of specific distinctness. As a species or group they are entirely distinct from any other members of the section.

Species excludenda

STENOCHLAENA FEEGEENSIS Brack. Filices U. S. Expl. Exped. 78. *pl. 11. f. 1.* 1854. (Type from the Fiji Islands, *Wilkes Exped.*)

The synonymy and distribution of the species of § *Lomariopsis* of the Old World are given in an alphabetical series:

8. **Stenochlaena Brackenridgei** (Carruth.) [FIGURE 4.]
Lomariopsis Brackenridgei Carruth. Fl. Vit. 373. 1871. (Type from the Fiji Islands.)
RANGE: Known only from its type locality.

9. **Stenochlaena buxifolia** (Kunze).
Acrostichum buxifolium Kunze, Die Farrnkr. 1: 171. *pl.* 72. 1845. (Type from Madagascar.)
ICON.: Kunze, *loc. cit.*
RANGE: Known only from Madagascar.

Polypodium orbiculatum Poir. Encyc. Méth. Bot. 5: 525 (type locality, Java) is referred to this species as a synonym by Kuhn, but in the absence of any type specimen and with a widely different type locality it is much safer to leave the matter in abeyance.

10. **Stenochlaena cochinchinensis** (Fée).

Lomariopsis cochinchinensis Fée, Mém. Foug. **2**: 66. *pl. 26.* 1844–5. (Type from Cochin China, *Herb. Mus. Paris.**)

ICON.: Fée, *loc. cit.*

RANGE: Cochin China; known only from the original collection by Gaudichaud.

11. **Stenochlaena decrescens** (Baker) [FIGURE 5.]

Acrostichum decrescens Baker, Syn. Fil. 412. 1868. (Type from the Cameroons, West Tropical Africa, *Mann 1391.*)

RANGE: Known only from its type collection (Kew).

12. **Stenochlaena guineensis** (Kuhn) [FIGURE 3.]

Lomariopsis guineensis Kuhn, Fil. Afr. 53. 1868. (Type from Fernando Po, *Mann 139.*)

Acrostichum guineense Carruth. Cat. Afr. Pl. Welwitsch **2**: 276. 1901.

Foliar pinnae 10 × 3 cm.; sporophyllary pinnae 10 cm. × 4 mm.

RANGE: Fernando Po, St. Thomas, Congo, Angola and Sierra Leone. Sterile fragments from the last named region at Kew have much larger pinnae 17 × 4 cm., but are not otherwise distinct.

13. **Stenochlaena Hügelii** (Presl) Fée in herb. Vindob. [FIGURE 9.]

Lomariopsis Hügelii Presl, Epim. Bot. 263. 1851. (Type from New Zealand, *Hügel.*)

Lomariopsis sorbifolia var. resectum [*sic*] Christ in Warburg, Monsunia **1**: 56. 1900. (Type from Cairns, North Queensland, *Warburg 19286.*)

This clearly marked species, which naturally has no near resemblance to *S. sorbifolia* of the American tropics, was well characterized by its author in the corrections to the text of *Epimeliae Botanicae*, and for this reason has eluded discovery for a long time. A long manuscript description under a new name by F. Mueller appears in the Kew herbarium with specimens from Rockingham

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* We were unable to find the type in Paris collected by Gaudichaud, but there is a cotype in the herbarium at Berlin.

Bay, Queensland. Warburg's specimens represented at the Berlin herbarium differ mainly in having somewhat shorter pinnae with their upper basal angle more truncate than in Presl's plant. The venation and margins of the pinnae suggest *Plagiogyria*, but there is apparently no indusium. It forms a clearly marked species from a region inhabited by no other species of this section.

14. **Stenochlaena leptocarpa** (Fée).

Lomariopsis leptocarpa Fée, Mém. Foug. **2**: 69. *pl. 29.* 1844–5. (Type from the Philippines, *Cuming 132.*)

Lomaria spectabilis Kunze, Bot. Zeitung **6**: 144. 1848. (Type from Pangarango, Java, *Zollinger 3130.*)

Lomariopsis spectabilis Mett. Fil. Hort. Bot. Lips. 22. 1856.

Acrostichum spectabile Racib. Pter. Fl. Buitenzorg 54. 1898.

ICON: Fée, *loc. cit.*

RANGE: Java and the Philippines.

We have not seen Fée's own specimen of this species, which is now in storage with the Cosson herbarium at the Paris Museum. This number of Cuming in the general collection of the herb. Mus. Paris, does not agree with Fée's excellent figure, but is clearly *S. Smithii.* Original specimens from Mettenius' herbarium agree perfectly with Fée's plate, as does Raciborski's recent excellent description.

15. **Stenochlaena lomarioides** (Bory) [FIGURE 6].

Acrostichum lomarioides Bory, Belang. Voy. Bot. 21. *pl. 2.* 1833. (Type from Ile de France, *Belanger.*)

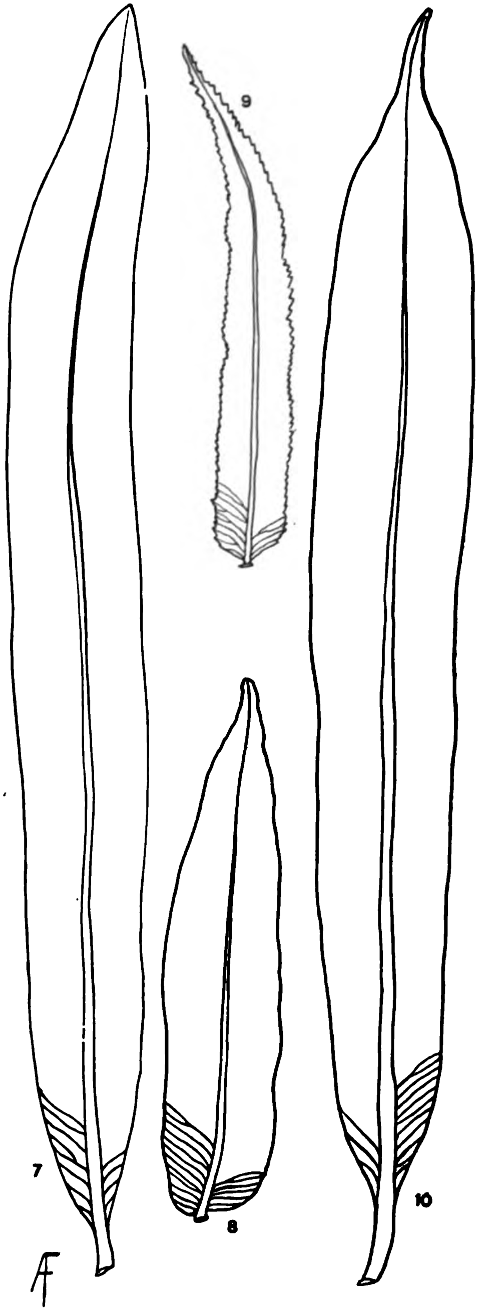
Lomariopsis Boryana Fée, Mém. Foug. **2**: 68. 1844–5. (Specific name changed from the above without apparent warrant.)

ICON.: Bory, *loc. cit.*

RANGE: Bourbon.

16. **Stenochlaena Mannii** sp. nov. [FIGURE 2.]

Stems stout, climbing, 1.5 cm. or more in diameter, densely covered with dark-brown scales; stipes scattered, stout, 20–30 cm. long, densely covered with similar dark-brown scales; sterile leaves pinnate, about 19-jugate, the pinnae closely placed, up to 17 cm. long by 2 cm. or more wide, the lowest two or three pairs slightly shorter, the upper gradually reduced to 3–5 cm. long, the terminal similar but larger (8 cm. long); pinnae rounded-truncate at the base, gradually tapering to an acute point, margins undu-



Some of the species confused under *Stenochlaena sorbifolia*. Normal lateral pinnae, natural size. 7. *S. Novae-Caledoniae*. 8. *S. pollicina*. 9. *S. Hügelii*. 10. *S. oleandrifolia*.

late, midribs with occasional scales; rachis strongly margined above, more or less scaly throughout; sporophyls pinnate, the pinnae 26-jugate, gradually diminishing above and below, the longest (medial) 11 cm. long by 5–7 mm. wide at the rounded base, tapering gradually to a point; rachis similarly scaly and margined above.

FERNANDO PO: 5,000 ft., 1860, *Mann 354* (type), K (three sheets) *ibid.* 3,000 ft. *446*, K.

CAMEROONS: *Kalbreyer 188*, K (slightly smaller; sterile leaves 28-jugate); *H. H. Johnston 146*, K (still smaller; sterile leaves only, 24-jugate.)

17. **Stenochlaena Novae-Caledoniae** (Mett.) [FIGURE 7.]
Lomariopsis Novae-Caledoniae Mett. Ann. Sci. Nat. IV. **15**: 58. 1861. (Type from Poila, New Caledonia, *Vieillard 1529.*)

RANGE: Known only from its type collection. The species resembles *S. Pervillei* in the form of the pinnae, but differs widely in the sporophyls.

18. STENOCHLAENA OLEANDRIFOLIA Brack. Filices U. S. Expl. Exped. 75. 1854. (Type from the Fiji Islands, *Wilkes.*) [FIGURE 10.]

RANGE: Fiji Islands and New Hebrides.

19. **Stenochlaena Pervillei** (Mett.) [FIGURE 1.]
Lomariopsis Pervillei Mett.; Kuhn, Fil Afr. 53. 1868. (Type from the Seychelles Islands, *Perville 98.*)

RANGE: Known only from the type locality.

20. **Stenochlaena pollicina** (Willemet) [FIGURE 8].
Osmunda pollicina Willemet, Ann. Bot. Usteri 6^{18}: 61. 1796. (Type locality, Mauritius, Mt. Pollex?.)
Lomaria fraxinea Willd. Sp. Pl. **5**: 294. 1810. (Type locality, Mauritius, and also cites *Osmunda pollicina* as a synonym!)
Lomaria integrifolia Kaulf.; Sprengel, Syst. Veg. **4**: 63. 1827. (Type from Mascarine Islands.)

RANGE: Mauritius, Bourbon, Madagascar, Mascarene Islands.

21. **Stenochlaena Seemannii** (Carruth).
Lomariopsis Seemannii Carruth. Fl. Vit. 373. 1873. (Type from the Fiji Islands, *B. Seemann 712*).

RANGE: Fiji Islands and New Hebrides.

22. **Stenochlaena Smithii** (Fée).

Lomariopsis Smithii Fée, Mém. Foug. **2**: *71. pl. 33. f. 2; pl. 53.* 1844–5. (Type from the Philippines, *Cuming 143.*)

ICON: Fée, *loc. cit.*

RANGE: Philippine Islands.

23. **Stenochlaena variabilis** (Willd.).

Lomaria variabilis Willd. Sp. Pl. **5**: 294. 1810. (Type from Mauritius.)

Osmunda trifrons Bory, Voyage **3**: 163. 1804. (*Nomen nudum.*)

Lomariopsis variabilis Fée, Mém. Foug. **2**: *70. pl. 31. 32.* 1844–5.

Lomariopsis cuspidata Fée, Mém. Foug. **2**: 68. *pl. 27.* 1844–5. (Type from Mauritius.)

ICON: Fée, *loc. cit.*

RANGE: Known only from Mauritius.

We cannot separate Fée's two species, of which he gives excellent plates; the type number of his *L. cuspidata* (*Sieber 22*) is also cited under *L. variabilis!*

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LUCIEN M. UNDERWOOD,
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NEW YORK CITY.

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OF COLUMBIA UNIVERSITY—No. 223

THE SPECIES OF LYCOPODIUM OF THE AMERICAN TROPICS

By LUCIEN MARCUS UNDERWOOD and
FRANCIS ERNEST LLOYD

NEW YORK
1906

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 33: 101-124. 1906]

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 33 : 101–124. 1906.]

The species of Lycopodium of the American tropics

LUCIEN MARCUS UNDERWOOD AND FRANCIS ERNEST LLOYD

In 1900 we published a preliminary list of the West Indian species of *Lycopodium* in connection with a revision of the species of temperate North America.* During the few years that have since elapsed, our knowledge of the tropical species has been greatly extended, chiefly through the explorations that have been made in various parts of the West Indies under the direction of the New York Botanical Garden. The expeditions to Porto Rico by Underwood and by Wilson, to St. Kitts by Britton and Cowell, to Cuba, by Britton, Shafer, and Wilson, and by Underwood and Earle, to Haiti by Nash, to Jamaica by Underwood and by Maxon of the United States National Museum, and to Dominica by Lloyd have all brought back an extensive array of material. This has been amply supplemented by the Jenman collection purchased by the Garden in 1903, which is specially rich in material from Jamaica, Grenada, Martinique, and Guiana. Other recent South American material has been supplied through the rich collections of H. H. Smith in the Santa Marta region of Colombia, and of R. S. Williams in the Andean region of Bolivia. The latter collection particularly has brought to light a number of very interesting species. American collections are still lacking in good representative material from Brazil, and there are occasional species from other regions about which additional light is still greatly desired. In order to place our present knowledge in an accessible form, we present this second preliminary report on the species of the West Indies and Mexico, and have included occasional species from South America. The West Indian forms are now fairly well limited and localized, yet it is not impossible or even unlikely that still other species will be found in the archipelago when the higher altitudes of the larger islands shall have been explored. The Mexican and especially the Central American species are much more obscure, and must await further exploration. The same is even more true of South America, which is likely to yield species yet unknown, as well as much more definite information about many that are now only imperfectly known.

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* LLOYD, F. E. & UNDERWOOD, L. M. A review of the species of *Lycopodium* of North America. Bull. Torrey Club 27 : 147–168. 1900.

All descriptions of structural characters are based upon material prepared by boiling, and upon glycerin-jelly microscopic preparations, of which in all instances camera-lucida drawings were made to a uniformly applied scale.

The three sections of the genus *Lycopodium* that are represented in the American tropics may be distinguished as follows:

- **Foliage leaves normally many-ranked, mostly uniform.**
  - **Sporangia in the axils of unaltered leaves.** § 1. *Selago.*
  - **Sporangia aggregated in distinct terminal strobiles whose bracts differ widely from the foliage leaves.** § 2. *Lepidotis.*
- **Foliage leaves 4–5-ranked, dimorphous; stems strongly dorsiventral.** § 3. *Diphasium.*

§ 1. SELAGO

The northern types of this group are familiar in the boreal *Lycopodium Selago* and the more common *L. lucidulum* of the Northern States. *L. porophilum* is a more restricted and local plant somewhat intermediate between the other two species. The tropical representatives are more numerous, a very few simulating the northern species in habit, while a much greater number become epiphytic and are pendent from trees. The species * of meridional America may be separated as follows:

- **Plants with radial symmetry; leaves not twisted.**
  - **Plants terrestrial in habit.**
    - **Leaves short, 1 cm. or less long.**
      - **Plants erect or ascending; leaves rigid.**
        - **Leaves in 16–20 ranks; stems short and rather stout.**
          - **Leaves serrulate, strongly hooked at the ends.** 5. *L. densifolium.*
          - **Leaves straight, with entire margins.** 4. *L. Sieberianum.*
        - **Leaves in 8 ranks, serrulate; stems elongate.**
          - **Leaves reflexed or loosely spreading.**
            - **Leaves verticillate, distant, closely coiling when dry.** 3. *L. polycarpum.*
            - **Leaves scattered, crowded, reflexed-spreading; sporangia 1.2 mm. wide.** 1. *L. reflexum.*

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* A number of the species from South America are omitted here, owing largely to lack of sufficient material. The following members of this group are more or less perfectly represented in the herbarium of the New York Botanical Garden in addition to the species tabulated below: *L. compactum* Hook., *L. rufescens* Hook., *L. erythraeum* Spring, *L. tetragonum* Hook., *L. crassum* H.B.K., *L. Hartwegianum* Spring, *L. filiforme* Sw.

Leaves rigid, thick, ascending; sporangia 1.8 mm. wide. 2. *L. rigidum.*

Plants spreading or pendent; leaves lax, somewhat secund. 9. *L. portoricense.*

Leaves longer, 1.5 cm.

Leaves linear, 0.6–0.8 mm. wide. 6. *L. montanum.*

Leaves lanceolate, 1 mm. wide. 7. *L. hippurideum.*

Plants epiphytic, pendent from trees.

Leaves short, 8 mm. or less long.

Plants with slender, many times dichotomous stems.

Plants 60 cm. or more long.

Strobiles compact; sporophyls short, triangular. 10. *L. Pringlei.*

Strobiles lax; sporophyls slender, subulate. 8. *L. setaceum.*

Plants short, under 20 cm. long; leaves very narrow, scattered, widely spreading. 20. *L. Williamsii.*

Plants with thick cord-like stems, closely dichotomous.

Leaves slender, flaccid. 17. *L. funiforme.*

Leaves broader at base, rigid. 16. *L. Picardae.*

Leaves larger, 1–3 cm. long.

Stems red, robust; leaves 2.5 cm. long, sharply reflexed from near the base. 12. *L. pithyoides.*

Stems green.

Leaves and sporophyls 4-ranked. 15. *L. nitens.*

Leaves and sporophyls 6–10-ranked.

Leaves rigid, closely appressed. 14. *L. cuernavacense.*

Leaves lax, spreading.

Leaves narrow, less than 0.5 mm. wide. 19. *L. Wilsonii.*

Leaves wider, 0.5–1 mm. wide; midrib prominent. 18. *L. dichotomum.*

Plants more or less dorsiventral by the twisting of the leaves.

Leaves sharply twisted at the base, usually narrowed below.

Plants short, 25 cm. or less long.

Stems short, dichotomous from near the base; leaves crowded, short and rigid; midribs prominent. 13. *L. Orizabae.*

Stems lax; leaves scattered, widely spreading, broadest at the middle, less than 1 cm. long; sporophyls similar. 23. *L. tenuicaule.*

Plants elongate, 35–80 cm. long; leaves lax, with less conspicuous midribs, long-tapering.

Leaves straight or slightly arcuate, 1.5–3 mm. wide, with inconspicuous midribs. 21. *L. linifolium.*

Leaves strongly arcuate, widely spreading, narrow (1 mm.), with conspicuous midribs; sporophyls short (8 mm.), slender. 22. *L. Jenmani.*

Leaves twisted throughout their entire length, widest at base. 11. *L. taxifolium.*

1. LYCOPODIUM REFLEXUM Lam. Encyc. Meth. Bot. **3**: 653. 1789. (Type from Martinique, *Martin.*)

Lycopodium squarrosum Sw. Nov. Gen. et Sp. Pl. 137. 1788.—Fl. Ind. Occ. **3**: 1571. 1806. (Type from Jamaica, and cites same plates as Lamarck.) Not *L. squarrosum* Forst. 1786.

Lycopodium reflexum Willd. Sp. Pl. **5**: 52. 1810. (Type from "Amer. merid."; apparently described independently by Willdenow, overlooking Lamarck's name.)

Lycopodium bifidum H. & B.; Willd. Sp. Pl. **5**: 53. 1810. (Type from "Amer. merid.")

Lycopodium eversum Poir. Encyc. Meth. Bot. Suppl. **3**: 556. 1813. (Based on *L. reflexum* Willd. not Lam.)

Lycopodium reversum Presl, Rel. Hænk. **1**: 82. 1825. (Type from Guayaquil.)

In the above long synonymy we have a hint of wide distribution and a considerable degree of variability, which was aggravated by the citation in Lamarck's original description of two plates that did not belong to the species, which he described as having reflexed leaves, viz.: Plumier, Fil. *pl. 166, f. A*, and Dillen, Hist. Musc. *pl. 57, f. 4*, which were later separated as a distinct species.

RANGE: Cuba (*Wright 933*), Porto Rico, Jamaica, Haiti (*Nash 557*), Guadeloupe (*Perrin*), Mexico, Guatemala (*J. D. Smith 504, Maxon 3560*), Colombia, Bolivia.

2. LYCOPODIUM RIGIDUM Gmelin, Syst. Nat. ed. 13. **2**: 1289. 1791. (Founded on Dillen, Hist. Musc. *pl. 57, f. 4.*)

This figure of Dillen represents the rigid form of the plant, which has often passed as *L. reflexum*. Dillen's figure according to his own statement is copied from Plumier (Fil. *pl. 166, f. A.*), so that by some *L. rigidum* might be regarded as a synonym of *L. reflexum* Lam.*

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* In the whole matter of the determination of types a certain amount of plain ordinary common sense must be used. In this instance we have in the West Indies two closely allied plants whose imperfect original descriptions both cite the same plates. One plant has notably *reflexed* leaves while the other has *rigid* leaves. It was evidently this character in each case that suggested the names *reflexum* and *rigidum*. Lamarck clearly had the plant whose leaves are lax and consequently become reflexed as they mature. His plant, collected in Martinique by Martin, if in existence will serve as a type of his species. But he added to his description, citations from Plumier and Dillen drawn evidently from the species with rigid erect leaves, which Gmelin later

RANGE: Jamaica (*Wilson, Jenman, Underwood 181*), [Martinique?, *Plumier*]. This plant is apparently less common and less widely distributed than *L. reflexum.*

3. **Lycopodium polycarpum** (Sod.) sp. nov.

Lycopodium reflexum γ polycarpum Sod. Crypt. Vasc. Quitenses 569. 1893. (Type from Ecuador.)

A terrestrial plant with verticillate distant leaves 35–40 cm. high. Stem rather slender, 1.5 mm. or less thick, four times dichotomous, the ultimate divisions elongate; leaves and sporophyls distant, in nearly regular whorls, about 8-ranked, 4–5 mm. long by 0.8 mm. wide, linear-lanceolate, acute, serrulate, recurved, in drying bent back to form a semicircle; sporangia reniform, 1.5 mm. wide, laterally exceeding the sporophyls in width.

ECUADOR: 1899, *Sodiro* (type); *Spruce 4973.*

We have excellent specimens from Father Sodiro which show a relation to *L. reflexum* but are amply distinct as a species. The large sporangia coupled with the distant leaves make the former unusually prominent, a fact that is recorded in the name. The species is apparently most closely related to *L. intermedium* Spring, of which we have not seen the type, but in any case that name is antedated by *L. intermedium* Blume, by a number of years.

4. LYCOPODIUM SIEBERIANUM Spring, Monog. Lycop. 1: 23, *excl. syn.* 1842. (Type from Martinique, *Sieber 56.*)

Spring apparently confused with specimens of a very distinct species, various figures, some of which had already served as types of other species. On receiving a very distinct plant from St. Kitts we had thought at first to describe it as new on the strength of these citations, but on examination of *Sieber 56* at Berlin the past summer (the plant on which Spring based his name and in part his description) we find that our St. Kitts plant

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separated as *L. rigidum*, basing his description on Dillen's plate which was taken direct from Plumier. In the absence of type specimens there are many who would make the two names synonyms, and rename Gmelin's species. But to one familiar with both plants in the field the names *reflexum* and *rigidum* assume greater importance and significance. The liability of error in interpretation in the purely "literary revision" of plant names without the supplemental knowledge of the plants themselves, receives here a capital illustration, and all such revision is to be deprecated. Plain common sense would suggest the continuance of the two names accepted above as representing the spirit of the founders of the two species concerned.

agrees perfectly, so that it is necessary to retain Spring's name with an emended application. We have therefore drawn up a fresh description from a recently collected plant:

A stout terrestrial plant with 2–3 forks, and leaves crowded in about 20 ranks. Stems 20 cm. or more long; leaves 5 mm. long or more by 0.8 mm. wide at the base, entire, tapering to an acute apex, spreading, slightly ascending, curved dorsiventrally at the base and near the apex; sporangia reniform, exceeding the sporophyl in width by only a small amount.

MARTINIQUE: *Sieber 56* (specimens in herb. Berol.); *Hahn 1263* (specimens in herb. Kew).

ST. KITTS: Mt. Misery, among ferns, *Britton & Cowell 547*. Only a single plant was collected, but its characters are so strikingly different from *L. reflexum* and *L. rigidum*, its nearest allies, that we do not hesitate to take up Spring's name for it as representing a valid species. This plant is no doubt included by Baker in his description of *L. rigidum*, and Hahn's plant above cited was found under the cover of *L. rigidum* at Kew. We have not seen the plants from Peru and Chile, cited by Spring, so can give no details of its distribution further than recorded above. The habitat of the plant seems to be the volcanic craters of the Lesser Antilles. The exact locality of Sieber's plant is not recorded. Hahn's plant came from Mont Pelée and the St. Kitts specimen was found in the similar crater of Mt. Misery. It probably will be found on all the volcanic mountains of this group.

5. **Lycopodium densifolium** (Baker) sp. nov.

Lycopodium reflexum var. *densifolium* Baker, Handbook of Fern Allies 11. 1887.

A terrestrial plant 35 cm. or less tall, 2–4-dichotomous. Stems stout, 4–6 mm. or more in diameter exclusive of the leaves; leaves in about 20 ranks, crowded, 4–5 mm. long by 1 mm. wide at base, tapering from a point one fourth the length from the base to the acute mucronate apex which appears obtuse from above or below owing to the excessive curvature, stiff, spreading at right angles to the stem, strongly curved upward (or nearly hooked) at the apex, thickened dorsiventrally throughout the curve; margins with a few (1–5) short triangular multicellular straight or reflexed teeth near the base, and a few others more widely scattered throughout the length; sporangia broad, mostly confined to the upper portions of the stems.

ECUADOR: 1857–9, *Spruce 5429*. A unique species, with rigid leaves wholly unlike *L. reflexum*, under which name it was distributed. In the Kew Herbarium Mr. Baker has marked this number of Spruce as *L. reflexum* var. *densifolium*, a conclusion no one could have reached from Mr. Baker's brief description of the plant.

6. **Lycopodium montanum** sp. nov.

A terrestrial shade plant, 30–40 cm. high, with decumbent bases and dark-green foliage. Stems 2–3 mm. thick, once or twice forked, the older portions becoming decumbent and ultimately dying away while the newer parts are nearly erect, the whole stems often 70–90 cm. long with dark-green foliage; leaves 1.5 cm. long by 0.7–0.8 mm. wide, linear, acuminate, spreading, at length reflexed, downwardly curved near the tips, the midrib not evident in the dry material but distinct when moist; sporophyls like the leaves, the sporangia much exceeding the sporophyls in width, 1.5 mm. broad and nearly as deep.

JAMAICA: Summit of Blue Mountain Peak in deep shade, *Underwood 2537* (type), *2542; Nock* (in herb. Jenman).

Near to this species are the closely allied specimens from Bolivia (*Mandon 1528*) and Ecuador (*Sodiro*), which probably belong to *L. Lechleri* Hieron., a species recently described. *L. hippurideum* Christ is also a closely allied species.

This plant was apparently first collected in Jamaica by Nock in 1880 on the ridge of Blue Mountain Peak. Mr. Jenman confused this elegent terrestrial species with the epiphytic and remotely related *L. dichotomum*, and when the latter species was brought in from Grenada he was inclined to regard it as undescribed, as he had evidently not seen the true *L. dichotomum* from Jamaica, where it appears to be rather rare. The two species have very little in common and this elegant plant is one of the handsomest of the terrestrial species, growing in large patches in the shade of the dense forest that covers the summits of the Blue Mountain range.

7. LYCOPODIUM HIPPURIDEUM Christ, Prim. Fl. Cost. 3^1: 56. 1901. (Type from Costa Rica, *Pittier 10619*.)

COSTA RICA: El Páramo, 3000 m., Massif de Buena Vista, *Pittier 10619*. Known only from its type locality. There is a cotype in the United States National Herbarium.

8. LYCOPODIUM SETACEUM Lam. Encyc. Meth. Bot. 3: 653. 1789. (Type from the Antilles and Bourbon; but Plumier, Fil. *pl. 166, f. B*, as well as Dillen, Hist. Musc. *pl. 56, f. 3*, is cited.) Not *L. setaceum* Hamilton, 1825.

Lycopodium acerosum Sw. (Fl. Ind. Occ. 3: 1575. 1806; type from Bourbon) may be the same species, since Swartz cites the same plates as Lamarck and states that Dillen also had it from the West Indies. Swartz in Syn. Fil. (1806) refers both *L. setaceum* and *L. acerosum* to *L. verticillatum* L. fil. (Suppl. 448. 1781; type from Bourbon), but this is described as having "*foliis quadrifariis*," which will not apply to the plant of the American tropics. Since the time of Swartz, the American plant has been referred to *L. verticillatum*, probably incorrectly; at least the name *L. setaceum* is the earliest that it is safe to take up in the absence of any material from Bourbon.*

RANGE: Cuba (*Wright 935, Eggers 5173*), Jamaica (*Jenman*), Martinique (*Père Duss*), Haiti (*Nash 664*), Dominica (*Lloyd 342, 697, 808, 810*).

9. **Lycopodium portoricense** sp. nov.

A bushy but slender pale-green terrestrial pendent plant with subsecund leaves. Stems less than 1.5 mm. in diameter, covered to the bases with leaves, several times dichotomous, 30 cm. or more long; leaves and sporophyls alternating in zones, the leaves linear, acuminate, 6–8 mm. long by 0.3–0.4 mm. wide, more or less secund; sporophyls tapering gradually from a base 0.6 mm. wide to the apex, 6 mm. long; sporangia round-reniform, 1.3 mm. wide by 1 mm. deep.

PORTO RICO: Road from Guyama to Cayey, pendent on banks, *Underwood & Griggs 434* (type); Luquillo Mts., *Percy Wilson 141*.

This species is related rather closely to *L. setaceum*, but differs in its longer leaves, which are truly linear and not tapering from the base, in its larger stems, and in its terrestrial habit.

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* Since the time of Swartz it has been quite common to refer West Indian and Central American pteridophytes to species originally described from Bourbon (Réunion) or Mauritius. When we come to examine typical material from those islands we invariably find it very different from the better known American forms referred to the same species. There is every *a priori* reason for supposing the two floras to be very distinct, and every new examination of pteridophyte types shows this supposition to be true.

10. **Lycopodium Pringlei** sp. nov.

Epiphytic, pendulous, of slender open habit; stems 40 cm. or more long, about five times dichotomous, appearing cord-like from the appressed leaves; leaves subulate, 2.5–3 mm. long, 0.6 mm. wide, about 6-ranked; strobiles more or less interrupted, the shoots becoming variable in thickness because of the large crowded sporangia; sporophyls triangular, entire, 1.3 mm. long or less, 0.8 mm. wide at base, exceeding the sporangia only by their short apices, appressed except when distended by the ripened sporangia; sporangia nearly circular, 0.8 mm. wide by 0.6 mm. deep, sometimes slightly protruding beyond the margins of the sporophyls.

MEXICO: Hanging from oaks, Sierra de Clavellinas, 9000 ft., Oaxaca, *Pringle 4994* (type); Orizaba, *Müller 361*. A plant collected at Morelos, *Rose 4416*, is either this or very closely allied.

The plant was distributed by Pringle as *L. verticillatum*, but does not show close relationship to any of the West Indian plants bearing that name or that have been referred to that species. It is a much smaller-stemmed plant than *L. nitens*, and has 6-ranked instead of 4-ranked leaves and sporophyls as in that species.

11. LYCOPODIUM TAXIFOLIUM Sw. Nov. Gen. et Sp. Pl. 138. 1788.—Flor. Ind. Occ. **3**: 1573. 1806. (Type from Jamaica; in the latter work Swartz also says "*etiam in insula St. Helena.*")

While there is very great variation in the length of the leaves, often resulting in the appearance of much more slender stems, we cannot distinguish among the specimens from the West Indies the *Lycopodium passerinoides* H.B.K. (Nov. Gen. **1**: 41. 1815), the type of which was from Peru, and quite likely represents a plant widely different from the West Indian things that in recent years have been referred to it.

RANGE: Cuba, Hispaniola, Porto Rico, Jamaica, Dominica, St. Vincent, Grenada, Mexico, Colombia.

12. LYCOPODIUM PITHYOIDES Schlecht. & Chamisso, Linnaea **5**: 623. 1830. (Type from Jalapa, Mexico, *Schiede & Deppe.*)

MEXICO: Santa Maria, *Schaffner*; Orizaba, *Müller 691*.

GUATEMALA: *Seler 2329*.

CUBA: Santiago, *Hamilton 247*.

This characteristic species, long neglected or overlooked at Kew, is so clearly defined that one wonders at the oversight.

The plant from Cuba, though a fragment, is unmistakable, and shows an unexpected and unusual distribution.

13. **Lycopodium Orizabae** sp. nov.

A short rather stout epiphyte 16 cm. or more tall, with abundant lanceolate leaves. Stems 2–3 mm. thick at the base, more slender above, 3–4 times dichotomous, rising from dense clusters of roots; leaves 1.5–1.8 cm. long by 2–2.3 mm. wide, lanceolate-acuminate, broadest near the base, thence abruptly narrowed at the base, asymmetric, the midrib slender but evident almost to the apex, the margins entire; sporophyls similar to the leaves, but shorter and narrower, 1 cm. long by 1 mm. wide, lanceolate, broadest near the middle, acuminate, twisted at the base, slightly asymmetric; sporangia reniform, 1.8 mm. wide by 1.5 mm. deep.

MEXICO: Orizaba, *Müller 690.* Known only from its type collection.

14. **Lycopodium cuernavacense** sp. nov.

An elongate rigid epiphyte, with stiff appressed leaves. Stems attaining 60 cm. or more long, 3–4-forked, the branches diverging at a very small angle, rather stout, 3–4 mm. thick; leaves crowded, somewhat appressed, rigid, 2 cm. long by 2 mm. wide, subulate-acuminate, broadest at the base, the midrib evident by a furrow when dry, the margins entire; sporophyls similar to the leaves but shorter, about 1 cm. long; sporangia circular, slightly exceeding the sporophyls in width.

MEXICO: Morelos; trees in mountains above Cuernavaca, 8,500 ft., *Pringle 7613.*

This species is related to *L. taxifolium*, for which it was distributed, but differs from that species both in habit and in structural characters.

15. LYCOPODIUM NITENS Schlecht. & Chamisso, Linnaea **5**: 623. 1830. (Type from Jalapa, Mexico, *Schiede & Deppe.*)

Of this species we have seen only an original specimen, a sheet of which is at Kew. Its four-ranked leaves and sporophyls render it a striking plant.

16. LYCOPODIUM PICARDAE Christ, Bot. Jahrb. **24**: 148. 1898. (Type from Haiti, *Picarda 978.*)

We have a portion of the original collection made in 1892 (*Picarda 978*) whose label reads "Haiti prope Keurcoff in caverna, alt. 1,200 m."

17. LYCOPODIUM FUNIFORME Chamisso; Spring, Monog. Lycop. 1: 50. 1842.

The name was given by Chamisso to a plant in herb. Bory which was marked "California"; to this Spring in publishing the description added "Guadeloupe, *L'Herminier*" which should be regarded as the type locality. The plant is a well known Antillean species and the "California?" was evidently a mistake as the plant is apparently endemic in the West Indies.

RANGE: Cuba (*Wright 943*, *Pollard & Palmer 168*, *Underwood & Earle 658*, *1033*), Porto Rico (*Heller 1084*, *Percy Wilson 102*), Guiana (*Jenman*).

The living plant is well named, as the resemblance to cordage is very striking.

18. LYCOPODIUM DICHOTOMUM Jacq. Hort. Bot. Vind. 3: 26. *pl. 45.* 1776. (Type from Martinique.)

RANGE: Cuba (*Wright 944*), Hispaniola (*Nash 680*), Jamaica (*Clute 64*), Dominica (*Lloyd 506*, *798*, *809*, *819*), St. Kitts (*Britton & Cowell 304*), Grenada (*Sherring*), Guadeloupe (*Dr. Madiana*), Martinique, St. Vincent (*Smith 735*), Mexico (*Schaffner 3*, *Pringle 3976*), Guiana (*Jenman*).

There is some degree of variation present in this species. We were at first inclined to separate the St. Kitts plant as distinct and with it would go the scrap from Guadeloupe here cited from the Torrey herbarium. As noted above, Mr. Jenman confused the plant which we have described as *L. montanum* with this species, and then in his herbarium referred the Grenada plants really belonging here to a new name, *L. grenadense* Jenm. It is probably more logical to consider all the forms as coming under a single species.

19. **Lycopodium Wilsonii** sp. nov.

A small epiphyte with divergent forking branches and slender leaves. Stems 8–15 cm. long, about 2 mm. thick, with about three forks, the branches divergent; leaves linear, 1.5–1.8 cm. long by 0.6 mm. wide, very gradually tapering from the base to the acuminate apex, symmetrically or slightly curved; sporophyls similar to the leaves, but smaller, 1 cm. long by 0.4 mm. wide; sporangia round-reniform, 1.5 mm. wide by 1.3 mm. deep, exceeding the sporophyls in width.

PORTO RICO: Luquillo Mountains, *Percy Wilson 271* (type), *153*.

This species is perhaps nearest to *L. dichotomum*, varying in the direction of *L. setaceum*, but widely different from either in habit and structure. We dedicate it to its enthusiastic collector, whose visit to Porto Rico was productive of several novelties in the genus *Lycopodium*.

20. **Lycopodium Williamsii** sp. nov.

A small slender much-branched epiphyte 10–15 cm. long. Stems slender, pendulous, less than 1 mm. thick, sparsely covered with foliage below, hidden by the copious sporangia above; leaves scattered, slightly curved, widely spreading or descending, 7–9 mm. long by 0.5 mm. wide, linear, acute, with entire margins; sporophyls shorter, 4–6 mm. long by 0.3 mm. wide, linear; sporangia round-reniform, prominent, relatively large, 1 mm. wide by 0.8 mm. deep.

BOLIVIA: New Brazil, 5,500 ft., *Williams 1393*.

This beautiful moss-like species was collected by Mr. R. S. Williams on the Conway expedition in 1902, and we are pleased to recognize his discriminating field-work which shows itself in most beautifully prepared specimens, a form of work only possible when a trained botanist is sent to the field, and is not hampered by the necessity of collecting "sets of plants" for commercial or exchange purposes.

21. LYCOPODIUM LINIFOLIUM L. Sp. Pl. 1100. 1753. (Type from "Amer. merid." based on Dillen, Hist. Musc. *pl. 57, f. 5*, and Plumier, Fil. *pl. 166, f. C.*)

RANGE: Cuba, Hispaniola (*Nash 195* *), Porto Rico, Jamaica, Grenada, Trinidad, Mexico, Guatemala, Colombia, Venezuela, Guiana, Bolivia.

22. **Lycopodium Jenmani** sp. nov.

A slender pendent much-branched epiphyte with attenuate branches. Stems very slender, 1 mm. thick, much branched, with scattered leaves and contracted sporophyls; leaves arcuate, lanceolate, acuminate, 1–1.3 cm. long by 1–1.2 mm. wide, unsymmetrical, the midrib nearer one margin, widely spreading, distinctly curved, twisted at the base so that the blade lies in the plane of the axis; sporophyls twisted like the leaves, linear, much smaller at the ends of the branches, but ultimately attaining the size of the smaller leaves; sporangia reniform, 1.5 mm. wide by 1 mm. deep, much exceeding the leaves in width and thus appearing very conspicuous in the mass of foliage.

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* These specimens collected by Mr. Nash are simply superb developments of this beautiful species, the multitudinous branches of a bushy plant rising from a single stem all represented on the sheet, and strikingly in contrast with the old-fashioned "tips" of branches that constitute too many of the herbarium specimens of a past generation. Such specimens as these really give one some idea of the habit and true character of the living plant.

BRITISH GUIANA: Moruca River, *Jenman.*

Mr. Jenman had marked this plant in his herbarium as a distinct variety of *L. linifolium*, but the name assigned being untenable as a specific name in the genus, we are pleased to dedicate it to the memory of this most assiduous of students of the pteridophytes of the British colonies in America, whose collection and critical notes and publications add so much to our exact knowledge of the tropical pteridophyte flora of America.

23. **Lycopodium tenuicaule** sp. nov.

A lax slender epiphyte with delicate scattered leaves. Stems springing from a small cluster of roots, 20–30 cm. long, loosely branched, smooth, 1 mm. thick, the shoots dorsiventral by the twisting of the leaves at their bases; leaves 7–9 mm. long by 1.5 mm. wide, lanceolate, broadest at the middle or just above, acute, slightly unsymmetric, entire, twisted at the base so as to bring the blade to the plane of the axis, widely spreading, scattered, all sporangiate except on the oldest part of the stem; midrib slender, scarcely evident beyond the middle of the leaf: sporangia reniform, 1.3 mm. wide by 1 mm. deep.

DOMINICA: Mt. Diablotin, *Lloyd 878* (type).

PORTO RICO: Luquillo Mountains, *Percy Wilson 139.*

This delicate and graceful species which has appeared from two rather distant and distinct stations is very unlike any other West Indian species, forming a peculiar type with no near congeners.

§ 2. LEPIDOTIS

The tropical American species of this section fall somewhat naturally into four groups which are widely separated from each other in habit. We may separate these groups synoptically as follows:

- Species epiphytic, pendent from trees; leaves dorsiventral. **Phlegmaria Group.**
- Species of terrestrial habit.
  - Stems erect, usually naked at the base; habit tree-like. **Cernuum Group.**
  - Stems creeping.
    - Stems wide, trailing, with ascending branches. **Clavatum Group.**
    - Stems short, prostrate, with simple monostachyous branches. **Iulliforme Group.**

PHLEGMARIA GROUP

This group with strongly dorsiventral leaves is largely represented in South America, but one of the species extends into the West Indies. They may be separated as follows:

- Leaves broadly oval or obovate.
  - Leaves small, 3.5 by 2.5 mm.; sporophyls scarcely exceeding the sporangia.
    - Leaves narrowed (cuneate) at the base. 24. *L. cuneifolium.*
    - Leaves rounded at the base. 25. *L. callitricaefolium*
  - Leaves larger, 6–8 by 3–5 mm.; sporophyls extending into a point beyond the sporangia.
    - Sporophyls long, often attaining 20–40 cm.; leaves mostly regular. 26. *L. aqualupianum.*
    - Sporophyls short, 1–2 cm.; leaves obtuse or nearly so, irregularly spreading. 27. *L. dichaeoides.*
- Leaves lanceolate or lanceolate-ovate.
  - Leaves 2 mm. or more wide; sporophyls extending beyond the sporangia into a long point. 29. *L. roraimense.*
  - Leaves under 2 mm. wide; sporophyls shorter than the sporangia. 28. *L. subulatum.*

24. LYCOPODIUM CUNEIFOLIUM Hieron. Bot. Jahrb. **34**: 572. 1905. (Type from Costa Rica, *Hoffmann 50.*)

COSTA RICA: Vulcan de Barba, *Hoffmann 50;* with no locality, 1900, *C. Wercklé.* A plant nearly allied to *L. callitricaefolium* but readily separated by its more distant narrowly obovate leaves.

25. LYCOPODIUM CALLITRICAEFOLIUM Mett. Ann. Sci. Nat. V. **3**: 309. 1865. (Type from Bogota, Colombia, *Triana.*)

RANGE: Ecuador (*Spruce 4792*, *Sodiro*), Colombia, Costa Rica (*Warscewicz 12.*)

26. LYCOPODIUM AQUALUPIANUM* Spring, Monog. Lycop. **1**: 68. 1842. (Type from Guadeloupe, *L'Herminier*, and Hispaniola, *Neckour.*)

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* This name is probably a misprint for *guadalupianum* to which form Fée changed it in 1866; Urban (1903) writes it "*guadeloupeanum.*" We retain the original orthography as safer.

RANGE: Cuba (*Wright 936, Eggers 5165*), Porto Rico (*Sintenis 1546, Percy Wilson 155*), [Hispaniola, Guadeloupe], Bolivia (*Rusby 458*). The last named plant is sterile but cannot be separated by its foliage; it is distinct from *Mandon 1529*, which is *L. subulatum.*

27. LYCOPODIUM DICHAEOIDES Maxon, Proc. Biol. Soc. Washington **18**: 231. 1905. (Type from Guatemala, *Cook & Griggs 251.*)

GUATEMALA: Alta Verapaz, near Sepacuité, *Cook & Griggs 251*; between Sepacuité and Secanquim, *Maxon & Hay 3268.* Known only from these two collections now in the United States National Herbarium.

28. LYCOPODIUM SUBULATUM Desv. Encyc. Bot. Suppl. **3**: 544. 1813. (Type from "Amer. merid.")

Represented in typical form in the herbarium of the New York Botanical Garden only by sheets of *Mandon 1529* from Bolivia. There are numerous variations, some of which have been described by Baker. Among these are two sheets from Ecuador collected by Sodiro, which are marked "var. *pastoense*," which differ from each other and must be compared with Baker's type before they can be definitely placed. They probably represent one or more distinct species.

29. **Lycopodium roraimense** sp. nov.

A long slender pendulous epiphyte with sporophyls much longer than the sporangia. Stems over 75 cm. long, 2–3 forked, dorsiventral (except in the sporophyllary region) by the twisting of the leaves, the strobile elongate (30 cm.) and radially symmetrical; leaves lanceolate-ovate, acute, 8–9 mm. long by 2.5 mm. wide, twisted at the base, entire, thin, the midrib slender but distinct; sporophyls triangular, small, 1.5–3.5 mm. long by 1–1.5 mm. wide, extending beyond the sporangia in a point, the margins entire; sporangia conspicuous, nearly circular, exceeding the sporophyls in width.

BRITISH GUIANA: Forest slopes near Roraima (*herb. Jenman*). This plant differs from *L. subulatum*, its nearest ally, in its wider leaves and much longer sporophyls.

CERNUUM GROUP

The species of this group have a close relationship among themselves and are quite isolated from other related species.

Baker,* with characteristic disregard of continental work, reduces all the species involved, to *L. cernuum*, with three varieties, in which citation and synonymy are sadly at variance with accuracy and correctness, and all ideas of geographic distribution are left to reckless abandon.

In 1861 Müller,† with characteristic German positiveness, set aside a Javan plant as the genuine type of *Lycopodium cernuum* L., characterized by having (1) "*Folia caulina squarrosa*" in common with most other species recognized, and (2) "*Amentis centripetali-evolutis*," a character claimed as peculiar to this species, but one difficult to follow in actual material. Further than this he established five new species all from the Old World, besides recognizing *L. marianum* Willd. from the Philippine Islands. The distribution of his five new species was as follows:

Lycopodium Heeschii K. Müll. (*loc. cit.* 164) — Sierra Leone.
Lycopodium secundum K. Müll. (*loc. cit.* 164) — Cape Colony, Natal.
Lycopodium sikkimense K. Müll. (*loc. cit.* 164) — Sikkim (India).
Lvcopodium Moritzii K. Müll. (*loc. cit.* 165) — Java.
Lycopodium Hupeanum K. Müll. (*loc. cit.* 165) — Borneo.

In Müller's paper the species of tropical America were not considered, and two earlier descriptions from the Old World were apparently disregarded, *viz*:

Lycopodium vulcanicum Blume, Enum. Pl. Jav. **2**: 266. 1828. (Type from Java.)

Lepidotis convoluta Beauv. Prodr. L'Aetheog. 108. 1805. (Type from "Les deux Indes.") Material in American collections is insufficient to determine the status of Müller's species, but a partial examination of European herbaria convinces us that some of them at least are valid.

Hieronymus has recently ‡ taken up the name *Lycopodium capillaceum* Willd. for the common American species, citing Spring's reference to Willdenow's herbarium note § and stating that Willdenow's plant was from "Nova Andalusia" (Venezuela) instead of "Ins. Marianis" as stated by Spring. After seeing

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* Handbook of Fern Allies 23. 1887.

† MÜLLER, KARL. Zur Kenntniss des *Lycopodium cernuum* L. Bot. Zeitung **19**: 161–165. 1861.

‡ Plantae Lehmannianae etc. Bot. Jahrb. **34**: 573. 1905.

§ Flora **21**^{1}: 165. 1838.

Ceylon material (for we must regard the Ceylon plant as the type of *Lycopodium cernuum*) in various European collections, commencing with that of Linnaeus at London, we are unable yet to point out differences other than minor ones between the plants of Ceylon and those of the West Indies. We are compelled against our tendencies to retain the name *cernuum* for the common species of the American tropics. Hieronymus has also separated two additional South American species, neither of which affect those which had been already separated by us.

The four species from America which we have examined may be separated as follows:

Leaves toothed; axes bristly; strobiles elongate (1.5–4 cm.). 31. *L. curvatum.*
Leaves entire; axes mainly smooth.
  Strobiles short (1 cm. or less), with deeply ciliate-laciniate sporophyls; branches slender. 30. *L. cernuum.*
  Strobiles longer (1.5–2 cm. or more); sporophyls slightly toothed; branches stout.
    Sterile branchlets elongate (5–10 cm.) and pendulous; leaves short and abruptly narrowed. 33. *L. pendulinum.*
    Sterile branchlets short, stout, dichotomously spreading; leaves longer, gradually tapering. 32. *L. tortum.*

30. LYCOPODIUM CERNUUM L. Sp. Pl. 1103. 1753. (Type from "Indiis"; the bulk of the citations commencing with Linnaeus' own Fl. Zeyl. and Dillen indicate that the East India plant is the one which represents the plant as known to Linnaeus and his predecessors. Plumier, Fil. *pl. 165 A* is cited later as an example of an American plant.*)

RANGE: (In America only) Georgia, Florida, Alabama, Mississippi, Cuba, Hispaniola, Porto Rico, Jamaica, S. Thomas, St. Kitts, Guadeloupe, St. Vincent, Dominica, Trinidad, Mexico, Panama, Colombia, Guiana.

31. LYCOPODIUM CURVATUM Sw. Syn. Fil. 178, 402. 1806. (Type from Jamaica.†)

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* As noted above this plant is the one to be renamed in case the American plant is ever distinguished from that of Ceylon.

† In publishing this species Swartz cites in synonymy (*loc. cit.* 178) *Lycopodium arboreum* Gmel. (a name apparently unpublished) and *Lepidotis convoluta* Beauv., a plant imperfectly described in Prodr. L'Aetheog. 108 (1805) from "Les deux Indes." Later (*loc. cit.* 402) Swartz in giving a fuller description cites Jamaica as the definite type locality. We cannot say whether *Lepidotis convoluta* Beauv. is distinct or not, but Swartz's type at least is Jamaican.

JAMAICA: Salt Hill (a mile off the Content road from Gordontown to Cinchona), growing in deep *Sphagnum*, 1903, *Underwood 157*.

The above collection represents, so far as known, the only one made in Jamaica since the time of Swartz. The fine material collected indicates a species abundantly distinct from that common in the vicinity on dry banks.

32. **Lycopodium tortum** Sieber, sp. nov.

A robust much-branched terrestrial plant with long pendent strobiles. Stems erect or ascending, a meter or more high, the secondary branches spreading, triangular in outline, attaining 20 cm. broad by 15 cm. high, repeatedly branched, the terminals inclined irregularly downwards and bearing the sessile strobiles; leaves on the older axes 5 mm. long by 0.5 mm. wide (on younger axes as short as 3 mm.) curved upwards and outward, becoming less curved and more widely spreading on the older axes, the curve commencing at about the middle, and the leaf tapering from above the middle to form an acute apex; margins entire; strobiles 1.5–2 cm. long, 3–4 mm. in diameter, cylindric or slightly angulate at the apex; sporophyls appressed, widely spreading, and but little curved when dry, 2.5 mm. long by 1 mm. wide, the margins irregular, with small scattered uneven teeth.

RANGE: Higher (volcanic) summits of the Lesser Antilles; specimens have been examined as follows:

ST. KITTS: Mt. Misery, *Britton & Cowell 550*.

GUADELOUPE: Mt. Perrin (*herb. Torrey*); 1898 (*herb. Jenman*).

DOMINICA: In old crater near Boiling Lake, Laudat, *Lloyd 315*.

MARTINIQUE: 1897 (*herb. Jenman*); *Sieber, Fl. Mixta 328* (*herb. Kew*).

ST. VINCENT: *H. H. & G. W. Smith 52*.

This species was long ago issued by Sieber under the above name, which in deference to him we have here taken up for the coarse plant of striking habit concerning whose distribution we have now quite definite information. In St. Kitts the species is locally known as "Stag Horn." This plant has been confused with *L. curvatum* Sw., the type locality of which (Jamaica) is quite outside the range of the peculiar species of the volcanic islands.

A second species allied to the last was collected in 1902 by Percy Wilson in the Luquillo Mountains, Porto Rico (*no. 101*), but the specimens are unfortunately in the vegetative condition only; it differs from this species in its much smaller size and in its strongly incurved leaves which are hairy on the lower surface near the base and often toothed. Mature strobiles are a desideratum.

33. LYCOPODIUM PENDULINUM Hook Ic. Pl. 1: *pl. 90.* 1837.* (Type from Casapi, Peru, *Mathews 1776.*)

RANGE: [Peru]; Cargadira, Bolivia, 8000 ft., *Williams 1386.* Mr. Williams' specimens show a unique plant, widely distinct in habit from any others of the group.

CLAVATUM GROUP

It is a difficult problem to distinguish many of the species of this group, a large proportion of which Baker reduces to the single species *L. clavatum*, whose distribution is curiously given as "Arctic and alpine zones of both hemispheres, also mountains of tropical Asia, Africa and America, Cape, Mascaren [*sic*] Isles and Polynesia." In Jamaica a form occurs from 5000 ft. upwards to the very summit of the Blue Mountains which at present we are not able to separate on structural grounds from our common northern species,† although it differs *toto coelo* in habit. In place of our unobtrusive close-creeping plant, the Jamaican form is rampant in great masses over the paths about the Cinchona plantation, forming a weed, and sprawling over low shrubs in the greatest profusion. Material from the whole world will be needed to elucidate the relations of the species involved in this polymorphic tangle. Besides abundant material from Jamaica we have imperfect collections from Mexico, Guatemala, Colombia, Guiana, Brazil, Ecuador and Bolivia, but insufficient for monographic purposes. For these reasons we prefer to leave the Jamaican plants for the present under

34. LYCOPODIUM CLAVATUM L. Sp. Pl. 1101. 1753. (Type from Europe).

RANGE: Europe and North America from the Arctic zone as far as Pennsylvania; also (provisionally) Jamaica above 5000 ft., and possibly Mexico and Guatemala.

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[*] L. Eichleri Fée, Crypt. Vasc. Bres. *pl. 106. f. 4*, cited by Baker as a synonym, is apparently distinct if Fée's plate is to be relied on, and his plates are usually extremely reliable. Mr. Baker further cites this species incorrectly as *L. pendulum.*

[†] With a distribution scattered well over the Northeastern States extending as far west as Washington State and Southward to Pennsylvania, this species is far from being either "arctic or alpine" in America, although it does attain both these regions in this country as in Europe.

IULIFORME GROUP

35. **Lycopodium iuliforme** sp. nov.

A low plant with short close-creeping stems and rigid upright monostachyous branches. Creeping stems 6–10 cm. long or more, with numerous roots throughout; leaves in 10 or more ranks, those of the lower surface pale, narrow, and somewhat lax, 2–2.5 mm. long, triangular-subulate from a wider base, those of the lateral surfaces ascending, twisted, 3–5 mm. long, somewhat rigid, ending in a firm acuminate point; erect branches terminal, or becoming apparently lateral from the innovating branches of the prostrate stems, 9–12 cm. high, leafy throughout, the leaves mostly 8-ranked, rather rigid, slightly spreading, 4–5 mm. long, lanceolate-acuminate; strobiles 3–3.5 cm. long, slightly thicker than the stems; sporophyls 8-ranked, lanceolate above from a broad base, the rigid apices wide-spreading; sporangia reniform, 1.5 mm. wide, entirely concealed by the broad base of the sporophyls.

GUIANA: Summit of Roraima, 8,600 ft., *McConnell & Quelch 572.* (Type at the New York Botanical Garden.)

A unique species forming a series of its own, intermediate in a way between the *Inundatum group* and the *Carolinianum group.* It was reported upon by C. H. Wright (Trans. Linn. Soc. II. **6**: 87. 1901) as *L. contiguum* Kl., with which it has only a remote alliance. *L. contiguum* has membranous-tipped leaves and sporophyls, the latter soft, lax, and wide spreading, and with conspicuously erose margins.

§ 3. DIPHASIUM

The members of the section *Diphasium*, which forms a physiological rather than a structural alliance, will group themselves somewhat naturally as follows:

Vertical stems simple; foliage shoots prostrate, creeping, the leaves of the two under rows larger and appearing lateral. **Carolinianum Group.**
Vertical stems much branched.
  Terminal foliage shoots with 4 rows of dimorphous leaves; upper surface with one row of leaves. **Complanatum Group.**
  Terminal foliage shoots with 5 (or 6) rows of leaves, the upper surface with three rows of reduced leaves. **Scariosum Group.**

CAROLINIANUM GROUP

The species of this group were referred by Baker to our familiar *L. carolinianum* of the Southern States, but will readily separate themselves into at least three species as follows:

Sporophyls serrulate; under leaves triangular, nearly as broad at base as long; sporangia round-renate. 36. *L. goyazense.*

Sporophyls entire.

  Sporangia depressed-renate; under leaves ovate, acute. 37. *L. meridionale.*

  Sporangia round-renate; under leaves lanceolate. *L. carolinianum.*

36. **Lycopodium goyazense** sp. nov.

A small creeping plant with stout erect branches bearing large strobiles. Creeping stems 6 cm. or more long, notably dorsiventral, producing occasional short branches; leaves strongly dimorphic, those of the two under rows appearing lateral, triangular, symmetric, 2 mm. wide at the base, not contracted, 2.5 mm. long, acute, entire, thick, somewhat imbricated; those of the three upper rows small, triangular, twice as long as broad or more, stiff, remote from each other and thus exposing the broad upper surface of the stem; erect branches (peduncles) 7–9 cm. long, 1.5 mm. thick, with triangular scale-like leaves which are 4 mm. long by 1.5 mm. wide at base and serrulate; strobiles 3–4 cm. long, stout; sporophyls larger than the lateral leaves, 2.5 mm. wide by 5 mm. long, ovate, acuminate, not contracted above the middle; margins serrulate throughout.

BRAZIL: Goyaz, *Glaziou 22644;* also less perfect specimens from Minas Geraes, *Claussen.*

37. **Lycopodium meridionale** sp. nov.

A small close-creeping, sparingly branched plant with solitary upright strobilary branches. Creeping stems up to 40 cm. or more long, 1–1.5 mm. thick, with occasional short (2–4 cm.) lateral branches; leaves strongly dimorphic, those of the two under rows appearing lateral, 5 mm. long by 2 mm. wide, ovate, acuminate, falcate, the midrib curved asymmetrically and parallel to the proximal leaf-margin; leaves of the upper four rows subulate, spreading, 3.5 mm. long by 1 mm. wide; upright branches (peduncles) 8–26 cm. long, oftener rising from the short prostrate branches, with whorls of subulate spreading scale-like leaves with parallel margins or slightly contracted below the middle, entire or slightly erose near the base; strobiles 2.5–8 cm. long; sporophyls 2 mm. wide by 4 mm. long, triangular, contracted at the middle and subulate above, spreading, the margins entire above, erose below the middle, those of the same level not contiguous.

RANGE: Probably widely distributed through the tropics of meridional America. Specimens have been examined as follows:

PORTO RICO: Dry savannahs, Luquillo Mountains, *Percy Wilson 94* (type) (two sheets); *Sintenis 1544.*

CUBA: *Wright 1819.*

DOMINICA: Laudat, high wet turf, Boiling Lake, *Lloyd 316.*

GUIANA: Wet ground, Essequibo, *Jenman* (two sheets).

BRAZIL: San Carlos and Rio Negro, *Spruce 3039*; Moritiba, *Blanchet 3470.*

(LYCOPODIUM CAROLINIANUM L., ranging from New Jersey to Texas, is not found outside of the Southern States, and is introduced in the above synopsis for comparison only.)

COMPLANATUM GROUP

The only member of this group in the West Indies we de scribed from herbarium material before having seen the plant in the field. Like *L. clavatum* of another group, *L. Fawcettii* forms a weed in the paths of the Cinchona plantation and grows luxuriantly, ascending over bushes and low shrubbery in a sprawling fashion and is thus quite in contrast with its more modest congeners of the Northern States. The status of *L. thyoides* H.B.K. of South America still remains to be determined. Our single West Indian species is

38. LYCOPODIUM FAWCETTII Lloyd & Underw. Bull. Torrey Club **27**: 167. 1900. (Type from Jamaica.)

This species is common in Jamaica from 5000 feet altitude to the extreme summit of the Blue Mountains. It has also been found in Hispaniola (*Wright, Parry & Brummel 37; Picarda 767; Eggers 2270*).

SCARIOSUM GROUP

The members of this group are mostly from tropical or south temperate regions. *Lycopodium scariosum*, with which Baker has confused the American species, is from New Zealand, and there are other Old World species. The American species are mostly South American, only a single species reaching Jamaica in the West Indies. The American species may be separated as follows:

Lateral leaves of the dorsiventral branches directed upwards, straight, rigid, tapering from the base, not sharply pointed nor crowded. 39. *L. Gayanum.*

Lateral leaves of the dorsiventral branches curved downwards.
  Leaves ascending, cuspidate, strongly revolute. 42. *L. Holtoni.*
  Leaves spreading, slightly curved.
    Lateral leaves broad near the apex, obtuse. 40. *L. lindsaeaceum.*
    Lateral leaves broadest at the decurrent base. 41. *L. Jussiaei.*

39. LYCOPODIUM GAYANUM Remy*; Gay, Hist. Chile Bot. **6**: 545. 1853. (Type from Chile, *Gay.*).

A single specimen in the Meissner (Columbia) herbarium from Valdivia, Chile, *no. 208* of "Bridges or Cuming?" represents this species in our collections as described, and shows characters warranting us in maintaining it.

40. LYCOPODIUM LINDSAEACEUM Spring, Flora **21**: 180. 1838. (Type from Peru.)

This species was united by Baker with the New Zealand *L. scariosum*, which naturally has little to do with the new world representatives of the group. The species is represented in the herbarium of the New York Botanical Garden by a single specimen collected by Rusby in Bolivia, and by several more recently brought from the same country by Williams.

41. LYCOPODIUM JUSSIAEI Desv. Encyc. Bot. Suppl. **3**: 543. 1813. (Type from Peru.)

We have specimens of this species collected by Spruce and Sodiro in Ecuador and were inclined for a time to separate Jamaica specimens collected by Purdie and by Jenman and more recently by Underwood and by Maxon. Jamaica material shows a marked differentiation in texture, the leaves being thinner, more distant, acute rather than mucronate, and inequilateral, *i. e.*, with the midrib nearer the anterior leaf-margin. In Jamaica the species is rare, growing at altitudes above 5000 feet. Baker (*loc. cit.*) reduced the species to a variety of *L. scariosum* of the Old World.

42. **Lycopodium Holtoni** sp. nov.

Main stems creeping, sending up lateral shoots 25 cm. or more tall, with foliage shoots ending in bifid peduncles; lateral (upper) leaves of the dorsiventral ascending branches crowded and imbricate, ascending, the lateral free margin revolute (so that the leaf appears strongly twisted in the dry condition), the upper surface arched, thick, coriaceous, cuspidate; ascending shoots 3–8 mm. wide, varying in diameter throughout the length; leaves of the under three rows 4–5 mm. long, 1.5 mm. wide at the base, awl-shaped, thin, scarious-margined and often slightly lacerate, the apices scarious or hair-like; strobiles 5–6 cm. long, 5 mm.

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* This species is usually referred to Remy and it is not likely that Gay would name a species after himself, but we have failed to find in this volume any evidence that Remy described this species.

thick, appearing ridged by the somewhat carinate sporophyls; sporophyls ovate, acuminate with a scarious lacerate tip and a narrow (1 mm.) claw, 5 mm. long, by 2.5 mm. wide, the margin slightly erose; sporangia depressed-triangular, 3 mm. broad by 1.75 mm. deep, folded and irregular, sessile.

COLOMBIA: In montibus juxta Bogotam, 7 Oct. 1852, *I. F. Holton 79.**

Unless otherwise noted all the above citations of specimens are from the combined herbaria of Columbia University and the New York Botanical Garden, now forming a single collection.

COLUMBIA UNIVERSITY.

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* The extensive collection of Isaac F. Holton was one of the first made in Colombia and has never been studied; a full set of the collections is in the Torrey herbarium; Holton went out from Middlebury College on a twenty months' trip through Colombia. He afterwards published an account of his travels which bears the following title: New Granada: twenty months in the Andes. New York, 1857. A copy has recently been added to the library of the New York Botanical Garden.

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* Nos 157 and 158, with the set of eleven papers by Mr. Bicknell on *Sisyrinchium*, can be had for one dollar and fifty cents.

Lists of titles of Contributions may be had on application.

LUCIEN M. UNDERWOOD,
Professor of Botany.

COLUMBIA UNIVERSITY,
NEW YORK CITY.

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CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
OF COLUMBIA UNIVERSITY—No. 224

THE GENUS VERNONIA IN THE BAHAMAS

By HENRY ALLAN GLEASON

NEW YORK
1906

[From the BULLETIN OF THE TORREY BOTANICAL CLUB 33: 183-188. 1906]

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The genus Vernonia in the Bahamas

HENRY ALLAN GLEASON

In the recent Bahamian collections made for the New York Botanical Garden is abundant material representing the genus *Vernonia* and including some interesting new forms. Dr. N. L. Britton has referred them to me for study and has also given numerous valuable suggestions concerning their specific characters. The specimens cited are all in the herbarium of the New York Botanical Garden.

In 1864 Grisebach, in the Flora of the British West Indies, described a species of *Vernonia* from the Bahamas as *V. bahamensis.* Since then numerous collections have been made and the species has been mentioned frequently in literature pertaining to the islands. It is, however, an aggregate, and three related but distinct species are represented in recent collections. In addition a second type, represented by a fourth species belonging to a widely different section of the genus, has recently been collected and demands recognition as new. A widely distributed tropical species, *V. cinerea,* is introduced in New Providence Island.

Vernonia bahamensis as characterized by Grisebach has the "heads single, sessile at the top of leafy branches." The two related species resemble it to some extent in this character. The three may together be regarded as members of the section *Lepidaploa,* subsection *Scorpioideae,* in which the scorpioid cymes have been much reduced, even to a single flower as in *V. bahamensis.* Indications of this reduction are seen in *V. longifolia* Pers. with its varieties *Sintenisii* Urban and *Vahliana* Urban of the Windward Islands and Porto Rico. The internodes of the cyme are shortened, and the heads are fewer than in typical scorpioid *Vernoniae,* and the whole inflorescence but little exceeds the upper foliage leaves. This group seems to be of equal rank with *Scorpioideae foliatae,* and *Scorpioideae aphyllae,* and the name *Scorpioideae reductae* will indicate the peculiarities of its inflorescence.

The fourth species, of the section *Lepidaploa*, subsection *Paniculatae*, with corymbose peduncled heads, is entirely different from the others and finds its nearest relatives in the United States.

The five species may be separated as follows:

Herbaceous; heads corymbose, peduncled.
  Leaves ovate, pubescent. *V. cinerea.*
  Leaves linear or oblong-linear, glabrous or nearly so. *V. insularis.*
Frutescent; heads sessile or nearly so, single or in small cymes.
  Inflorescence of many heads; leaves of an elliptical type, broadest at or near the middle. *V. arctata.*
  Inflorescence of few heads; leaves broadest above the middle.
    Leaves oblanceolate, spatulate, or narrowly obovate. *V. bahamensis.*
    Leaves very broadly obcordate. *V. obcordata.*

VERNONIA CINEREA (L.) Less. Linnaea **4**: 291. 1829.
Conyza cinerea L. Sp. Pl. 862. 1753.

This well-known introduced species differs from the other Bahamian forms in the ovate or ovate-oblong, petioled, undulate leaves. It belongs to the section *Tephrodes*, characterized by achenes without evident ribs. New Providence, *Earle 60.*

Vernonia insularis sp. nov.

§ *Lepidaploa*, *Paniculatae;* perennial by a horizontal rootstock; stem herbaceous or suffruticose, glabrous or minutely puberulent in the inflorescence, erect, 6–10 dm. high, simple or sparingly branched; leaves numerous, alternate, narrowly oblong-linear, entire, obtuse or sub-acute, mucronate, acute or narrowed at the sessile base, one-nerved or with faint lateral veinlets, green and essentially glabrous on both sides, 6–10 cm. long, 0.8–1.2 cm. wide, the upper somewhat smaller; inflorescence terminal, corymbose, lax; heads 4–25, on peduncles 0.5–4 cm. long; involucre at maturity broadly campanulate or depressed-hemispheric, about 5 mm. high; scales glabrous with membranous margins, the outer lanceolate, sharply acuminate, the inner oblong, abruptly acuminate or mucronate; achenes 2 mm. long, striate, sparsely pubescent; pappus tawny, 6 mm. long, the outer series minute.

Great Bahama, pine lands, Eight Mile Rocks, Feb. 5–13, 1905, *N. L. Britton & C. F. Millspaugh 2392a*, type, in fruit; same place and date, *N. L. Britton & C. F. Millspaugh 2392*, a more mature specimen with the achenes gone; same place, April 16–May 8, 1905, *L. J. K. Brace 3683*, young specimens only 2.5–3 dm. high, with the inflorescence just beginning to appear;

Abaco, pine lands, Marsh Harbor, Dec. 21, 1904, *L. J. K. Brace 1835*, past maturity with the achenes gone.

Abaco and Great Bahama islands, from which *V. insularis* only has been collected, are but a short distance from the east coast of southern Florida, and the nearest relative of the species may be looked for there. In leaf-habit and involucre it is not far from the Floridian *V. Blodgettii* Small, and may be connected phylogenetically with it.

Vernonia arctata sp. nov.

§ *Lepidaploa, Scorpioideae reductae;* a much-branched shrub 3–8 dm. high, stem and branches striate, thinly tomentose or glabrate, branches crowded, leafy; leaves broadly elliptic to obovate-oblong, acute or mucronate, entire, acute or obtuse at the base, pinnately veined, brown-tomentose beneath, glabrate above, 1–1.8 cm. long, 0.6–1.1 cm. broad, divaricately spreading or somewhat reflexed, on tomentose petioles 3–7 mm. long; inflorescence flattened, terminating the branches, consisting of several short leafy irregular scorpioid cymes bearing each 1–5 sessile or short-peduncled heads; involucre campanulate, 4–5 mm. high; scales pauciseriate, lanceolate, irregularly imbricated, acute, tomentose; achenes about 13 in each head, pubescent, 2.5 mm. long; pappus nearly white, 5 mm. long, the outer series conspicuous.

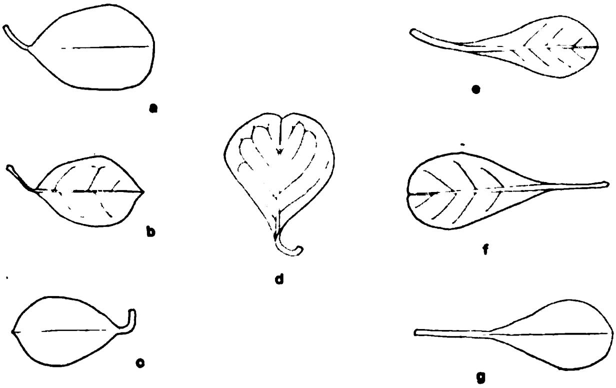

FIGURE I. Leaf types of (*a, b, c*) *Vernonia arctata*, (*d*) *V. obcordata*, (*e, f, g*) *V. bahamensis*. Natural size.

New Providence Island, in dry pine barrens. Most of the recently collected material distributed as *V. bahamensis* belongs here: *A. H. Curtiss 65*, Feb. 5, 1903 (type); *C. F. Millspaugh 2481*, Jan. 24, 1905: *Mrs. E. G. Britton 3275*, Feb. 3, 1905; *N. L. Britton & C. F. Millspaugh 2101*, Jan. 26, 1905; *N. L. Britton 6*, Apr. 7 and 8, 1904; *W. C. Coker 53*, June 20, 1903; *J. I. & A. R. Northrop 101*, Jan. 10, 1890; and two other sheets, in the herbarium of Columbia University, collected by Wm. Cooper.

Several branches usually arise near each other and are straight, virgate, very leafy, and about equal in length. Below the origin of the branches the leaves soon fall off. The inflorescence is sometimes 8 cm. across, and always exceeds the foliage leaves when fully developed. There is some variation among the specimens in the character of the branching but it appears to be due almost entirely to the relative age of the plants as shown by the time of collection.

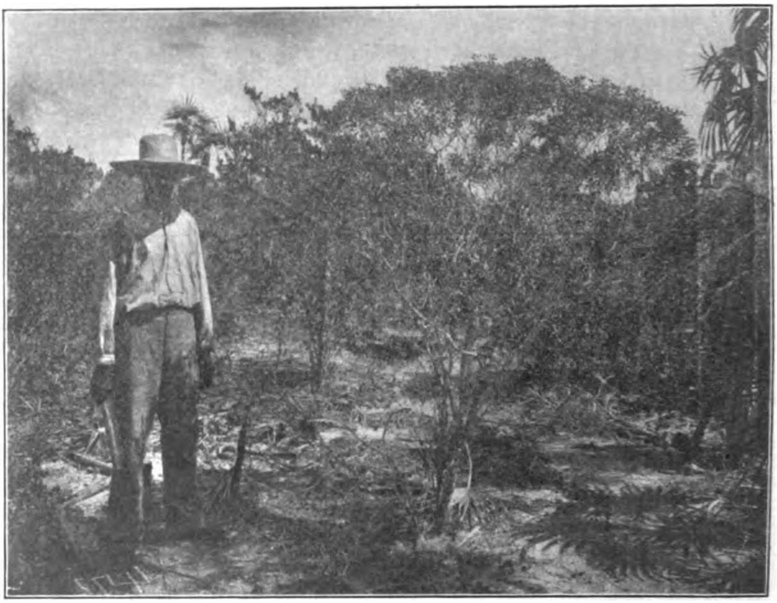

FIGURE 2. Habit photograph of *Vernonia bahamensis* Griseb.

Vernonia arctata is distinguished from *V. bahamensis* by the shorter and broader leaves, the character of the branching, and the conspicuous inflorescence with numerous heads.

VERNONIA BAHAMENSIS Griseb. Fl. Brit. W. Ind. 352. 1864.

A repeatedly dichotomously branched bushy shrub, reaching a height of 2 m. or more, with the leaves confined mostly to the young branches. Stem flexuous, thinly tomentose; younger branches strongly angled; leaves alternate, numerous, spatulate, oblanceolate, or narrowly obovate, entire, rounded at the tip and varying from mucronate to slightly retuse, narrowed at the base into a margined petiole, pinnately veined, tomentose on both sides, especially beneath, 2–3.5 cm. long, including the petiole, 0.5–1.2 cm. wide; heads few, seldom more than four on each branch, single, sessile among the upper leaves, with 13 flowers or fewer, usually 8; involucre campanulate, 3–4 mm. high; scales ovate-lanceolate, sharply acute, loosely imbricated in few series, tomentose; achenes densely hirsute, 2–2.5 mm. long; pappus nearly white, 4–5 mm. long, the outer series conspicuous.

Fortune Island, *Eggers 3832*, Apr. 2, 1888; Inagua, *Nash & Taylor 1017*, Oct. 14, 1904, and *1344*, Oct. 28, 1904.

Notes accompanying the specimens indicate that it grows in the so-called white lands, has purple flowers, and is locally known as white sage; the photograph, for which I am indebted to Mr. G. V. Nash, shows the general character of the plant.

The last cited specimen has been compared with the original collections in the Kew Herbarium, and pronounced identical by Sir William Dyer, and later also by Dr. N. L. Britton. Fortune Island and Inagua Island are near the southern end of the Bahamian archipelago, and the latter is not far from Haiti. As indicated by the specimens at hand, *V. bahamensis* and *V. arctata* are distinct not only in structure but also in geographical distribution.

Vernonia obcordata sp. nov.

§ *Lepidaploa, Scorpioideae reductae;* a much-branched shrub 6–9 dm. high, with stiff crooked branches, bearing leaves only on the young shoots; young branches strongly angled and tomentose, becoming terete and glabrous with age; leaves numerous, crowded, broadly obcordate, entire, narrowed at the base into a petiole 5 mm. long, pinnately veined, closely gray tomentose on both sides, especially beneath, blade 0.8–1.5 cm. long, 0.7–1.5 cm. wide, the cordation at the apex 2–3 mm. deep; heads few, single, sessile among the upper leaves, 8–13-flowered; involucre campanulate, 4–5 mm. high; scales ovate-lanceolate, acute, irregularly and loosely imbricated, tomentose; achenes as in *V. bahamensis*; pappus yellow.

Little Inagua, *Nash & Taylor 1206*, Oct. 20, 1904.

Vernonia obcordata is distinguished at once from the related species by the obcordate leaves, as broad as long, and by the yellow pappus.

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CONTRIBUTIONS FROM THE DEPARTMENT OF BOTANY
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AMERICAN FERNS—VI

SPECIES ADDED TO THE FLORA OF THE UNITED STATES FROM 1900 TO 1905

By LUCIEN MARCUS UNDERWOOD

NEW YORK

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB 33 : 189-205. 1906]

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[From the BULLETIN OF THE TORREY BOTANICAL CLUB, 33: 189–205. 1906.]

American ferns — VI. Species added to the flora of the United States from 1900 to 1905

LUCIEN MARCUS UNDERWOOD

Since the beginning of the serious study of our native ferns, there has probably been no similar period in which so many additions have been made to our flora as in the five years just passed. This has been due to several causes, the most important of which is the opening up to exploration of the really tropical portion of southern Florida, with the consequent addition of a large number of species mostly more or less common in the lowlands of the Bahamas and the Antilles. Some of the additions are due to the closer analysis which has been given in recent years to certain genera, particularly *Selaginella* by Professor Georg Hieronymus, *Isoetes* by Mr. A. A. Eaton, and *Botrychium* by the present writer. The proper delimitation of certain species of central and southern Florida has depended on special conditions. For example, while the writer was collecting in Florida during the winter of 1890–91, two species already known from that state were found growing together in similar situations on limestone rocks. Although these ferns had been referred, the one to a West Indian species and the other to a variety of the same, on collecting these species fifteen years ago the writer felt as fully as he does now (1) that the two had full specific distinctness, and (2) that the places to which they had been assigned by the "authorities" was not the correct one. Two essential conditions, however, were then lacking to justify their separation, and the writer has waited until these conditions might be changed:

1. It was essential for accuracy to make examination of certain types in European herbaria; this has not been practicable until the past summer; and

2. It was necessary to study a large collection of West Indian species of *Asplenium* in order to delimit the boundaries of related species. This has now become possible at home, for while the Kew herbarium and the Berlin collections, including the well

known West Indian herbarium of Krug and Urban, both contain material not found in any other, the collections now accumulated at the New York Botanical Garden exceed either, or both together for that matter, in the richness and completeness of the series of West Indian ferns.

A number of the species in the following list have already been reported by Mr. A. A. Eaton, whose collections in South Florida were partly listed in the Fern Bulletin for April, 1904; others have been reported by Mr. Maxon, by Mr. Gilbert, and by the writer, in various short notes. It is thought desirable to bring these together in a single list which will supplement the last (1900) edition of *Our Native Ferns and their Allies.* It will be noted that the list contains six genera and forty-nine species from the limits of the United States, not included in that work; two of these, however, displace species already reported under other names, so that the net increase is forty-seven species. Besides these a considerable number of varieties have been described; some of these are based on mere sports like the var. *Hortonae* of *Asplenium platyneuron*, and *Pellaea atropurpurea cristata*, while others may represent something more permanent in character. No attempt has been made to list these here. Among the forty-seven species, two are plants introduced from cultivation, which have apparently become locally established. One species of *Equisetum* and four species of *Selaginella* must be placed in the list of "*Species inquirendae*," inasmuch as they are imperfectly known. Removing these two doubtful series from the list there are still forty native species which represent *bona fide* additions to our known flora. The list follows, arranged in systematic order:

OPHIOGLOSSACEAE

BOTRYCHIUM ALABAMENSE Maxon, Proc. Biol. Soc. Washington **19**: 23. 1906. (Type from Mobile, Alabama, *Dukes.*)

BOTRYCHIUM CALIFORNICUM Underw. Torreya **5**: 107. 1905.

This species is the Californian plant hitherto mistaken for *B. silaifolium* Presl. *B. occidentale* Underw. becomes a synonym of the latter species, having been based on a tall-growing form.

BOTRYCHIUM ONONDAGENSE Underw. Bull. Torrey Club **30**: 47. 1903. (Type from Onondaga county, New York, *Underwood.*

RANGE: Central New York, northern Michigan, Montana (?).

BOTRYCHIUM TENUIFOLIUM Underw. Bull. Torrey Club **30**: 52. 1903. (Type from Alexandria, Louisiana, *Hale.*)

RANGE: Southern States from Alabama to Louisiana and Missouri. Closely related to *B. obliquum* Muhl.

SCHIZAEACEAE

ACTINOSTACHYS GERMANI Fée, Mém. Foug. **11**: 123. *pl. 29. f. 3.* 1866. (Type from Guadeloupe, *Deshaies*).

This remarkable discovery of Mr. A. A. Eaton in South Florida adds a fourth member of this family to our flora, and gives to a hitherto rare and local tropical species an unexpected distribution. Like *Schizaea pusilla*, this new species, although larger, is still so inconspicuous that it would be readily passed over by any except the most careful collector of ferns, and quite likely has a much wider range than has hitherto been attributed to it. The genus is closely related to *Schizaea* but has penicillate spikes.

LYGODIUM JAPONICUM (Thunb.) Sw. Jour. Bot. Schrader **1800**^{2}: 106. 1801.

Ophioglossum japonicum Thunb. Fl. Jap. 328. 1784. (Type from Japan, *Thunberg.*)

Escaped from cultivation near Thomasville, Georgia, and at several places near Mobile, Alabama, where it is growing like a wild plant. Mr. W. D. McNeill has sent me a fine series of specimens which were very naturally taken for a native species by their collector.

POLYPODIACEAE

POLYPODIUM HESPERIUM Maxon, Proc. Biol. Soc. Washington **13**: 200. 1900. (Type from Washington, *Gorman 642.*)

A segregate from *P. vulgare* which includes most or all of the forms hitherto referred to that species from the Rocky Mountains westward to the Pacific.

CAMPYLONEURUM LATUM Moore, Ind. Fil. 225. 1861. (Type from the West Indies.)

SOUTH FLORIDA: 14 miles south of Cutler, *A. A. Eaton.*

CAMPYLONEURUM COSTATUM (Kunze) Presl, Tent. Pterid. 190. 1836.

Polypodium costatum Kunze, Linnaea **9**: 38. 1835. (Type from Cuba, *Poeppig.*)

SOUTH FLORIDA: 5 miles north of Everglade, *A. A. Eaton.* Ranges also to Cuba and Jamaica.

CAMPYLONEURUM ANGUSTIFOLIUM (Sw.) Fée, Mém. Foug. **5**: 257. 1852.

Polypodium angustifolium Sw. Nov. Gen. et Sp. 130. 1788. (Type from Jamaica.)

SOUTH FLORIDA: 14 miles south of Cutler, *A. A. Eaton*, by whom it has been reported already. Ranges also to the Bahamas, Cuba, Jamaica, Hispaniola, and Porto Rico.

The four species of *Campyloneurum* now known from our flora may be distinguished as follows:

Leaves narrow, a centimeter or less wide.	*C. angustifolium.*
Leaves broad, 3–8 cm. wide or more.	
Veins obscure; texture opaque.	*C. costatum.*
Veins conspicuous.	
Leaves with a narrow wing, decurrent to near the base.	*C. Phyllitidis.*
Leaves long-stalked; areolae usually divided by a longitudinal vein.	*C. latum.*

ADIANTUM MODESTUM Underw. Bull. Torrey Club **28**: 46. 1901. (Type from Roswell, New Mexico, *Earle.*)

NEW MEXICO: Roswell, *Earle.*

ADIANTUM HISPIDULUM Sw. Jour. Bot. Schrader **1800^2**: 82. 1801. (Type from Australia.)

GEORGIA: Growing in a well near Thomasville, *R. M. Harper 1171.* Reported by Mr. Harper as established at this place.

A common species in cultivation and likely to become established in other favorable locations.

HYPOLEPIS REPENS (L.) Presl, Tent. Pterid. 162. 1836.

Lonchitis repens L. Sp. Pl. 1078. 1753. (Type from Martinique, based on Plumier *pl. 12.*)

This tropical fern, which becomes almost a climbing species in the West Indies, has been found in Florida by Mr. C. S. Williamson, as already reported (Torreya **3**: 18. 1903). He says of it: "It was quite abundant in the woods on the borders of Lake Apopka, which at Oakland is quite a distance from the town."

The plant resembles *Dennstaedtia* in habit, but has the indusium of *Cheilanthes*. The specimens sent by Mr. Williamson have a height of only 60 cm.

ASPLENIUM ANDREWSII A. Nelson, Proc. Biol. Soc. Washington **17**: 174. 1904. (Type from Boulder Creek, Colorado, *Andrews.*)

This new discovery from Colorado is a member of the *Adiantum-nigrum* group of *Asplenium* and is closely related to *Asplenium Adiantum-nigrum* of central and southern Europe. Among our species it will stand nearest *A. montanum.*

Asplenium verecundum Chapman in herb. sp. nov.

Rootstock short, erect or inclined, covered with more or less persistent bases of the leaf-stalks; leaves densely cespitose, bitripinnate, 16–40 cm. long, elliptic-lanceolate, 2.5–6 cm. wide, tapering both ways from the middle, borne on stalks 2–10 cm. long, which are smooth and brownish-purple as are also the rachises; pinnae (in larger specimens) bipinnate at base, gradually simpler outwards, or (in smaller specimens) pinnate throughout or with the basal pinnule 2–3-lobed or even divided into 2–3 segments; segments obovate or broadly oblanceolate, obtuse or rarely truncate at the apex and often mucronulate, decurrent on a narrowly winged rachis, bearing a single vein with a short sorus in or near the center; texture delicate, membranous; indusia rather broad, delicately membranous, with entire margins.

RANGE: Florida, northern, central, and southern; specimens have been examined as follows:

Jackson County: *Chapman* (type). Marion County: near Ocala, 1879, *Miss Reynolds; John Donnell Smith;* 1891, *Underwood 1810.* Scott's Spring near Ocala, 1891, *Underwood 1818.* Belleview, 1891, *Underwood 1876.* Hernando County: Istachatta, 1891, *Underwood 2001 b, 2001 c*; *Nash 1396 a.* Dade County: Biscayne Bay, 1887, *Isaac Holden;* 1888, *R. M. Monroe.* Between Cutler and Longview Point, 1903, *Small & Carter 854, 1156.* Miami, 1904, *E. G. Britton 91.*

With the original sheet of Chapman in the Columbia herbarium is a faded photograph marked "*Asplenium anchorita*, Scott's Well, near Ocala, Florida," and also "Rec'd from Miss Murray, Sept. 7, 1855." With this is a letter to Dr. Torrey from Amelia M. Murray, mentioning the collection of the fern at the above-named place. This interesting sink-hole later known as Scott's Spring, where the plant was evidently first collected, was visited in 1891 by the writer, who found the fern still growing there. It will be seen from the localities given that the plant ranges the entire length of the state. The name *anchorita* has been given as a synonym in the first edition of Chapman's Flora (page 593) and the highly appropriate name *verecundum* taken up from Chapman's herbarium was used as a *nomen nudum* in Fournier Mex. Pl. 111, in 1872. The fern is at once the most modest and the most graceful of our species of *Asplenium*.

Asplenium Curtissii sp. nov.

Rootstock short, erect or inclined; leaves 30–50 cm. long, bipinnate to tripinnatifid, lanceolate or lanceolate-ovate, 5–10 cm. wide, broadest a little above the base, the basal pinnae nearly as long as those above, borne on grayish-brown stalks 12–14 cm. long; pinnae lanceolate, in larger plants bipinnatifid, in smaller plants pinnate with 2–4-toothed or lobed closely-set pinnules; segments acute or rarely obtusish, pointed, decurrent on the rachises with a rather broad wing; veins single, or forked in the segments which are toothed, each tooth with a separate excurrent vein; sori prominent; indusia broad.

RANGE: Central Florida; specimens have been examined as follows:

Citrus County: Lake Tsala Apopka, *Curtiss 3728* (type). Marion County: near Ocala, 1879, 1883, *Miss Reynolds*. Indian Spring, 4 miles S. E. of Ocala, 1891, *Underwood 1813*. Belleview, 1891, *Underwood 1875*. Hernando County: Istachatta, 1891, *Underwood 1997, 2001, 2001 a;* 1897, *Curtiss 5683*.

The combined herbaria at the New York Botanical Garden contain seven sheets of *Curtiss 3728*, which represents the first plants collected and distributed. Two of these have a small plant of the previous species included on the same sheet, but the others are straight examples of the present species. We take pleasure in dedicating this very distinct species to Mr. Allen H.

Curtiss, whose botanical explorations in Florida have added so much to our knowledge. The species often grows in company with *Asplenium verecundum* Chapm., and we have collected the two growing together at three distinct localities. All the stations mentioned are within a circle whose radius is only twenty-five miles.

This species is readily distinguished from *Asplenium verecundum* by its shape, the lower pinnae not being reduced as in that species, by its larger size, coarser texture, and numerous other characters. It is scarcely necessary to add that the two plants have long posed under the names *Asplenium myriophyllum* or *A. rhizophyllum* either as species or varieties. *A. myriophyllum* is an entirely distinct species described originally from Jamaica. *A. rhizophyllum* (Thunb.) Kunze came originally from Dominica, and is a plant which roots from a prolonged apex as illustrated by Smith (Pl. Ic. Ined. **2** : *pl. 50*). The name, moreover, is preoccupied by *Asplenium rhizophyllum* L.

ASPLENIUM BISCAYNIANUM (D. C. Eaton) A. A. Eaton, Fern. Bull. **12** : 45. 1904.

Asplenium rhizophyllum var. *biscaynianum* D. C. Eaton, Bull. Torrey Club **14** : 97. *pl. 68.* 1887. (Type from Biscayne Bay, *Holden.*)

SOUTHERN FLORIDA. Collected at Biscayne Bay in 1887 by Isaac Holden, in 1888 by R. M. Monroe, in 1903 by A. A. Eaton, and in 1904 by E. G. Britton. Specimens of all these collections are represented in the herbaria at the New York Botanical Garden. There is a suspicion that this species may prove a hybrid of *Asplenium dentatum* L. and *A. verecundum* Chapm., both of which grow in its immediate vicinity. We agree with Mr. A. A. Eaton in recognizing this as a distinct species, nor should we differ did we know the above suspicion of hybridity to represent the truth of the matter. Species in taxonomy are the units of classification and their origin from others by variation, by hybridity, by mutation, or by any other process should have nothing to do with the simple taxonomic problem, while of the very highest interest in the biological history of the species.

ASPLENIUM MUTICUM Gilbert, Amer. Bot. **4**: 86. 1903. (Type from Bermuda.)

CENTRAL FLORIDA; also found in the Bermudas, whence it was described by Mr. Gilbert.

ASPLENIUM EROSUM L. Syst. Nat. ed. 10. **2**: 1324. 1759. (Type from Jamaica, based on Sloane, Voy. Jam. **1**: *pl. 33. f. 2.*)

CENTRAL FLORIDA: Cedar hammock, Sumpter County, 1894, *F. L. Lewton.*

This is the plant reported by Mr. Maxon in Torreya **3**: 185. 1903, and referred to a form of *A. auritum* Sw., and it represents one of the forms usually referred to that name from various West India islands. We have material similar to the Florida plant at least from Cuba, Jamaica, Hispaniola, and Porto Rico; much of the Jamaica material, however, which has been referred to *A. auritum*, is of quite a distinct type. In establishing *A. erosum*, Linnaeus based his name wholly on Sloane's plate; the plant of the present type, which agrees in every essential with Sloane's plate, must bear the name *A. erosum*, and, for the present, it will be left an open question as to whether all the so-called *A. auritum* Sw. of the West Indies and Mexico shall be merged under this name. It should be noted that Swartz cited the same plate of Sloane in establishing his *Asplenium auritum*, but in this case there is probably a specimen in Swartz's herbarium which will naturally take precedence of a cited plate in determining the type of the species. The name *Asplenium erosum* has unfortunately been used by various writers for species widely different from the one to which the name was originally given. We are fortunate to be able to get back to a real foundation for the application of the name. Sloane's plant is preserved in the British Museum.

CEROPTERIS VISCOSA (D. C. Eaton) Underw. Bull. Torrey Club **29**: 631. 1902.

Gymnogramme triangularis var. *viscosa* D. C. Eaton, Ferns of N. Am. **2**: 16. *pl. 48. f. 5.* 1880. (Type from Southern California.)

Stenochlaena Kunzeana (Presl) Underw. sp. nov.

Olfersia Kunzeana Presl, Tent. Pterid. 235. 1836 (*nomen nudum*).

Stems wide-climbing, more or less flattened, with occasional brownish scales when young, becoming smooth except for the abundant roots on the under surface; leaves 35–60 cm. or more long, oblanceolate, tapering both ways from above the middle, pinnate, borne on stalks 8–10 cm. long; pinnae 18- (or more) jugate, those of the upper portion lanceolate, 6–12 cm. long, 10–12 mm. wide, cuneate at the base, or long-tapering to a bordered stalk, irregularly and usually coarsely dentate, acute or acuminate at the apex, those of the lower portion of the leaf gradually reduced, the lowest becoming ovate or ovate-triangular, 1–2 cm. long; rachis winged especially when young, stramineous; midrib prominent, lateral veins oblique, simple or rarely forked about 1 mm. apart; sporophyls pinnate, the pinnae 6 cm. or more long, 5 mm. wide, borne on a short (3 mm.) stalk, midvein conspicuous, lateral veins distant, simple or usually forked at the base with the branches widely diverging.

Specimens have been examined as follows:

CUBA: 1822, *Poeppig;** *Wright 973* (type, in herb. D. C. Eaton "scandente arbores *Citri* ad 10 ped. in sylvis").

HISPANIOLA: "San Domingue" without collector or nearer locality, in herb. Mus. Paris; Plaisance, *Nash & Taylor 1492*.

PORTO RICO: *Balbis*, *Schwanecke*.

FLORIDA: Between Cutler and Longview Camp, 1903, *Small & Carter 856, 1157;* Ross' Hammock, Dade County, *A. A. Eaton 677*. All the Florida plants seen are sterile, but have the unmistakable foliage of this species.

The genus *Stenochlaena* thus added to our flora is related to *Struthiopteris* in its dimorphous simply pinnate leaves, but lacks an indusium; the sporangia soon become confluent on the narrow pinnae of the sporophyls and on this account the genus was merged by Hooker with *Acrostichum*, with which, however, it has no natural alliance. The Florida plants scarcely represent the norm of the species and apparently are straggling plants instead of climbing ones, as in more tropical forests.

DRYOPTERIS AQUILONARIS Maxon, Bull. Torrey Club **27**: 638. 1900. (Type from Cape Nome, Alaska, *Flett.*)

ALASKA: Once collected. A near relative of *Dryopteris fragrans*.

DRYOPTERIS PITTSFORDENSIS Slosson, Rhodora **6**: 75. 1904. (Type from Pittsford, Vermont, *Slosson.*)

Described as a hybrid of *D. spinulosa* and *D. marginalis*.

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* Poeppig's specimens were referred by Kunze (Linnaea 9: 59. 1835) to *Lomaria longifolia* Kaulf. and it was on the incorrectness of this determination that Presl wrote "*Olfersia Kunzeana* (*Lomaria longifolia* Kunze *nec* Kaulf.)" in 1836 (Tent. Pterid. 235). We have seen Poeppig's plants both at Prague and Vienna.

Other specimens of the same were collected by the writer in 1890 near Cambridge, Massachusetts, as noted in our collections by Dr. Philip Dowell, who collected the same thing on Staten Island, N. Y., in 1904. The species appears to stand on about the same basis as *D. Boottii.* Until the present turma of varieties, now connected with the variable *D. spinulosa*, can be made the subjects of more serious field study than they have yet received in this country, this name may well stand.

Dryopteris stipularis (Willd.) Maxon in herb.

Aspidium stipularis Willd. Sp. Pl. **5**: 239. 1810. (Type from Martinique, citing Plumier, *pl. 23.*)

FLORIDA: Miami, *A. A. Eaton.* Specimens seen in the U. S. National Museum.

DRYOPTERIS AMPLA (H. & B.) Kuntze, Rev. Gen. Pl. **2**: 812. 1891.

Polypodium amplum H. & B. in Willd. Sp. Pl. **5**: 207. 1810. (Type from Caripe, Venezuela.)

FLORIDA: Between Cutler and Longview Camp, 1903, *Small & Carter 834, 835.* Already reported by Mr. A. A. Eaton (*cf.* Fern. Bull. **12**: 46).

This species forms a short caudex like a tree-fern; the peculiar mass of cinnamon-colored matted scales at the base of the leaf-stalks is strikingly characteristic.

MENISCIUM RETICULATUM (L.) Schkuhr, Krypt. Gewächse 5. *pl. 5.* 1804.

Polypodium reticulatum L. Syst. Nat. ed. 10. **2**: 1325. 1759. (Type from Martinique and based on Plumier's figure.)

Dryopteris reticulata Urban, Symb. Ant. **4**: 22. 1903.

FLORIDA: Alapattah near Miami, 1903. *A. A. Eaton 779.* Already reported by Mr. Eaton (*cf.* Fern Bull. **12**: 46).

The genus *Meniscium*, established by Schreber in 1791, is well characterized by its venation and sori, the latter being linear and naked and borne on cross veins connecting the lateral parallel veins which extend from the midribs to the margin forming a series of similar areolae. The validity of the genus was never questioned until Diels, in placing it in its proper tribe, in our judgment went too far by uniting it with *Nephrodium*, from which it has more recently been transferred to *Dryopteris* by Professor Urban.

Tectaria minima sp. nov.

Rootstock creeping, knotty; leaves subcespitose, with slender smooth stramineous stalks 6–18 cm. long; lamina triangular, in larger leaves broadly so, 6–10 cm. long, 3–9 cm. wide, lobed at the base or in larger leaves bearing a pair of separate pinnae which are again slightly lobed below; margin of the terminal portion deeply crenate-incised in young leaves, in age becoming more deeply incised and with pointed rather than rounded divisions; veins everywhere irregularly areolate with numerous free included veinlets; main veins slightly fibrillose; sori arranged in a somewhat irregular row on either side the main lateral veins with occasional ones in the outlying space; indusium usually circular with a slit on one side forming a narrow sinus which is more often obscured by the overlapping folds.

Specimens have been examined as follows:

FLORIDA: Hammocks between Cutler and Longview Camp, 1903, *Small & Carter 855* (type); 10–14 miles south of Cutler, *A. A. Eaton 260.*

BAHAMAS: Conch Sound, Andros, *Northrop 562a;* Near Nassau, New Providence, *A. H. Curtiss 142;* Farringdon Road, New Providence, *E. G. Britton 3198;* Abaco, *Brace 1815.*

CUBA: Yumury, *Rugel 2;* near Ibarra, *Britton & Shafer 344.*

This species has been passed over in herbaria for young forms of *Tectaria heracleifolia* (Willd.), but proves to be a distinct species differing in habit, in size, in texture, in the character of the venation, and in the indusia, which are not strictly peltate as in that larger and more common species. Small leaves resemble those of *T. coriandrifolia*, but differ (1) in being sharp-pointed instead of blunt at the apex, (2) in the longer pointed basal lobes in marked contrast with the short rounded ones of *Tectaria coriandrifolia*, and (3) in the venation. Grisebach has marked the sheet collected by Rugel as "*Aspidium fimbriatum* Willd.," but if we can trust Plumier's *plate 149* this is a species widely different and wholly unknown in our day, and one which is to be looked for in future collections from Hispaniola.

[The plant hitherto known as *Tectaria trifoliata* in Florida and the West Indies cannot henceforth bear that name. The true *Tectaria trifoliata*, based on Plumier's *plate 148*, proves to be a wholly distinct species. This was suspected by some of the earlier writers on ferns, but still others have maintained that the discrepancies noted were due to the inaccuracy or possibly idealization of Plumier's artist. With the now abundant collections at hand from all parts of the West Indies there is no longer a doubt that we have two very excellent species and that Plumier's artist is again justified. Our Florida species (ranging throughout the West Indies) is **Tectaria heracleifolia** (Willd.). (*Aspidium heracleifolium* Willd. Sp. Pl. **5**: 217. 1810; type from Hispaniola, based on Plumier *plate 147*, which is an extreme form of the species.)

This species has uniformly peltate indusia. The true *Tectaria trifoliata* (L.) Cav. has indusia varying on the same plant from reniform with a very broad sinus to circular with a mere emargination on the side, thus breaking down the supposed distinctions between *Tectaria* and *Sagenia* as hitherto maintained. The true *T. trifoliata* ranges from Cuba (where we have collected it on El Yunque) and Porto Rico to Guadeloupe, Martinique, Dominica, St. Vincent, and Grenada. It differs in texture, form of lobes, venation, and indusia, and many of its characters were clearly portrayed in 1703 by Plumier, whose illustrations can now be easily interpreted with ample material of both species at hand.]

Tectaria coriandrifolia (Sw.).

Aspidium coriandrifolium Sw. Jour. Bot. Schrader **1800**^{2}: 36. 1801. (Type from Jamaica, citing Pluk. Alm. *pl. 284. f. 5.*)

FLORIDA: 14 miles south of Cutler, 1903, *A. A. Eaton 563*. The Florida plants are smaller and somewhat less divided than the ordinary Jamaican forms, while the plants from Cuba are quite intermediate between them.

ODONTOSORIA CLAVATA (L.) J. Sm. Hist. Fil. 264. 1875.

Adiantum clavatum L. Sp. Pl. 1056. 1753. (Type from San Domingo, based on Plumier's *pl. 101. f. b.*)

Davallia clavata Sw. Syn. Fil. 123. 1806.

SOUTHERN FLORIDA: 12–20 miles south of Cutler, *A. A. Eaton*. Already reported by Mr. Eaton (*cf.* Fern Bull. **12**: 47).

The discovery of this species in Florida adds the third representative of its tribe (*Davalliede*) to our flora. The narrow truncate and almost cuneate segments make it an easily recognizable species. We have gathered the fern in Cuba, Porto Rico and

Jamaica, and it has been brought in several times from the Bahamas.

HYMENOPHYLLACEAE

DIDYMOGLOSSUM * SPHENOIDES (Kunze) Presl, Hymenoph. 23. 1843.

Trichomanes sphenoides Kunze, Linnaea **9**: 102. 1835; Die Farnkr. **1**: 215. *pl. 88. f. 2.* 1846. (Type from Peru, *Poeppig.*)

FLORIDA: Between Cutler and Longview Camp, 1903, *Small & Carter 1478.* This species was reported by A. A. Eaton under *Trichomanes* (*cf.* Fern Bull. **12**: 47). It is a common lowland species of tropical America.

DIDYMOGLOSSUM * KRAUSII (H. & G.) Presl, Hymenoph. 23. 1843.

Trichomanes Krausii H. & G. Icon. Fil. *pl. 149.* 1831. (Type from Dominica, *Kraus.*)

FLORIDA: Between Cutler and Longview Camp, 1903, *Small & Carter 1479, 1500.* Also reported by Mr. A. A. Eaton under *Trichomanes* (*cf.* Fern. Bull. **12**: 47).

EQUISETACEAE

EQUISETUM FUNSTONI A. A. Eaton, Fern. Bull. **11**: 10. 1903. (Type from San Bernardino, Southern California, *Coville & Funston 13.*)

SOUTHERN CALIFORNIA: Not very well represented in our herbaria, but a number of sheets are found in the collection at Washington.

Species inquirenda

Equisetum Ferrisii Clute, Fern. Bull. **12**: 22. 1904. (Type from Joliet, Illinois, *Clute.*)

Not seen; judging from characters given, a very doubtful species described entirely from sterile material.

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* The genus *Didymoglossum* was established by Desvaux (Ann. Soc. Linn. Paris **6**: 330. 1827), and differs from typical *Trichomanes* in the possession of a distinctly bilabiate involucre which is contracted below the mouth and bordered by the tissues of the leaf. It has been adopted by all the writers who have seriously monographed the filmy ferns since the time of Desvaux.

SELAGINELLACEAE

SELAGINELLA ACANTHONOTA Underw. Torreya **2**: 172. 1902. (Type from North Carolina, *Curtis.*)

NORTH CAROLINA: *Curtis*, *Williamson.*

GEORGIA: Tattnall County, *R. M. Harper 1852;* Dooly County, *R. M. Harper 1957;* Montgomery County, *R. M. Harper 1987.*

SELAGINELLA HANSENI Hieron. Hedwigia **39**: 301. 1900. (Type from Fisher's Cabin, California, *Hansen 878.*)

CALIFORNIA: Collected in Calaveras, Fresno and Butte counties.

Selaginella Parishii sp. nov.

Plants prostrate, close-creeping, and emitting rootlets throughout, much branched, with mostly short stems; stems 6–10 cm. long, mostly with short alternate branches or sometimes with more compound ones; leaves with a dorso-ventral arrangement, brownish below, bright-green above, 5–6-ranked, curved upwards and coiling over the stems when dry, broadly lanceolate, acute, ending in a point but with no terminal bristle, but with 6–20 very short marginal hairs on either side; sporophyls on the ends of short branches, scarcely differing from the leaves, forming short subquadrate strobiles; microspores orange-yellow, 40–50μ in diameter, sphero-tetrahedral, long remaining united in tetrads; macrospores yellow globose, about 350μ in diameter.

CALIFORNIA: Palm Springs, Colorado Desert, March, 1903, *C. F. Saunders* (comm. S. B. Parish); dry rocky mountains in the desert, April, 1882, *Parish 1200.*

MEXICO: Conception del Oro, Zacatecas, Aug., 1904, *Palmer 306* (type).

This species has been known to the writer as distinct for a number of years, and was mentioned in the original breaking up of the group which had passed under the name of *S. rupestris* (*cf.* Bull. Torrey Club **25**: 133. 1898), among the *species inquirendae.* Mr. Parish has more recently sent me specimens with microspores, and from Palmer's recent collections the same plant turns up from Zacatecas with both microspores and macrospores; all the above-named plants are in the herbarium of the New York Botanical Garden.

SELAGINELLA SHERWOODI Underw. Torreya **2**: 172. 1902. (Type from Macon County, North Carolina, *Sherwood.*)

NORTH CAROLINA: Macon County, 1887, *J. Donnell Smith;* 1901–2, *W. L. Sherwood.*

SOUTH CAROLINA: *J. Donnell Smith.*

SELAGINELLA SCHMIDTII Hieron. Hedwigia **39**: 292. 1900. (Type from Sachalin, *Schmidt.*)

UNALASKA: *Chamisso.* Professor Hieronymus also described a var. *Krauseorum*, *loc. cit.* 293, which was collected in rock fissures on the river Tlehini, Alaska, by the Krause brothers in 1882.

SELAGINELLA UNDERWOODII Hieron. Die Nat. Pflanzenf. **1**^{4}: 714, note. 1901.

Selaginella rupestris Fendleri Underw. Bull. Torrey Club **25**: 127. 1898. (Type from Santa Fé, New Mexico, *Fendler 1024.*)

Selaginella Fendleri Hieron. Hedwigia **39**: 303. 1900. Not *S. Fendleri* Baker.

Colorado, New Mexico, and California; has been sent in by various collectors.

SELAGINELLA WALLACEI Hieron. Hedwigia **39**: 297. 1900. (Type from Oregon, *Wallace.*)

Oregon and Washington; has been sent in by recent collectors.

SELAGINELLA WRIGHTII Hieron. Hedwigia **39**: 301. 1900. (Type from New Mexico, *Wright 828.*)

Known only from its type collection.

Species inquirendae

The following species are known only from their original collections. It is perhaps better to await further collection and study before admitting them to full standing.

Selaginella montanensis Hieron. Hedwigia **39**: 293. 1900. (Type from Crossing, Montana, 1882, *Krause.*)

Selaginella Bourgeauii Hieron. Hedwigia **39**: 295. 1900. (Type from Fort Ellice, Oregon, *Bourgeau.*)

Selaginella Haydeni Hieron. Hedwigia **39**: 296. (Type from Nebraska, *Hayden;* also collected in Washington (then Oregon), *Lyall.*)

Selaginella Bolanderi Hieron. Hedwigia **39**: 300. 1900. (Type from Auburn, California, *Bolander 4511.*)

Selaginella sp.

FLORIDA: Dade County, *Small & Carter*, *A. A. Eaton.*

Erroneously reported by Mr. B. D. Gilbert as *Selaginella caribensis* Jenman, a species of the higher mountains of Jamaica (*cf.* Fern Bull. **13**: 74. 1905). We await a report on this interesting species from Professor Hieronymus.

Species excludenda

Selaginella Engelmanni Hieron. Hedwigia **39**: 294. 1900 = *S. densa* Rydb. and is therefore not to be included in the list except as a synonym.

ISOETACEAE

ISOETES OCCIDENTALIS Henderson, Bull. Torrey Club **27**: 358. 1900. (Type from Lake Coeur d'Alene, Idaho, *Henderson 5876.*)

Isoetes lacustris paupercula Engelm. Trans. Acad. Sci. St. Louis **4**: 377. 1882.

Isoetes paupercula A. A. Eaton, Proc. U. S. Nat. Mus. **23**: 649. 1901.

Colorado to California, Idaho, and Washington.

In accordance with the now established doctrine that *species* and not varieties are the units of classification, this name set aside under former rules should be restored. The writer wishes to record the fact that he has persistently opposed the principle of giving varietal names a standing in nomenclature since it was proposed at the Madison meeting and there voted. The pernicious effects of this principle have been fully appreciated by all who have tried it on any extensive scale.

ISOETES HETEROSPORA A. A. Eaton, Fernwort Papers 8. 1900. (Type from Jordan Pond, Mt. Desert Island, Maine, *Rand.*)

Known only from its type locality.

ISOETES HIEROGLYPHICA A. A. Eaton, Fernwort Papers 10. 1900. (Type from St. Francis Lake, Maine, *Pringle.*)

MAINE: Reported from several stations.

ISOETES GRAVESII A. A. Eaton, Fernwort Papers 14. 1900. (Type from Connecticut, *Graves*, *Underwood.*)

CONNECTICUT: Known from one or two ponds in western Connecticut. A fine series was collected by the writer some years ago at Tyler Pond, in Goshen, which is now in the herbarium of the New York Botanical Garden.

Species excludenda

Isoetes Harveyi A. A. Eaton, Fernwort Papers 11. 1900. (Type from Maine, *Harvey*.)

Mr. Eaton now regards this as a variety of *I. Tuckermani*, and we therefore exclude it from the list of species.

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